Materials

in Design Engineering

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

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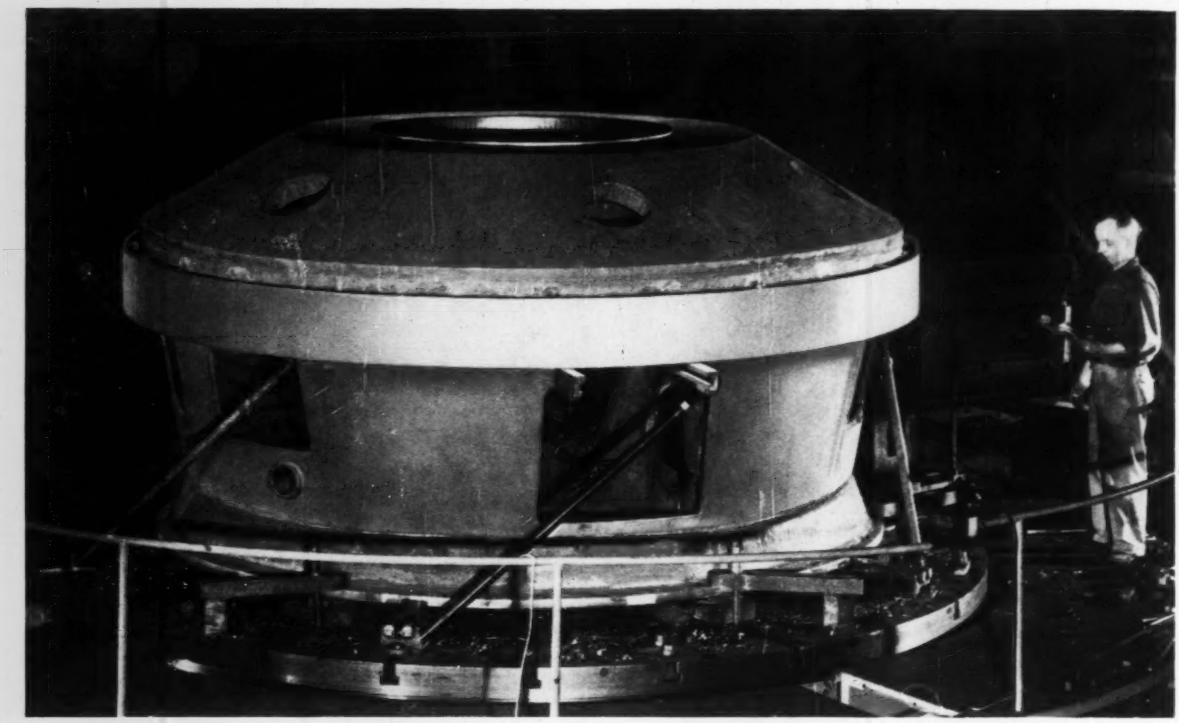

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JANUARY 1960 | VOL. 51, NO. 1

Materials in Design Engineering*

FORMERLY MATERIALS & METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

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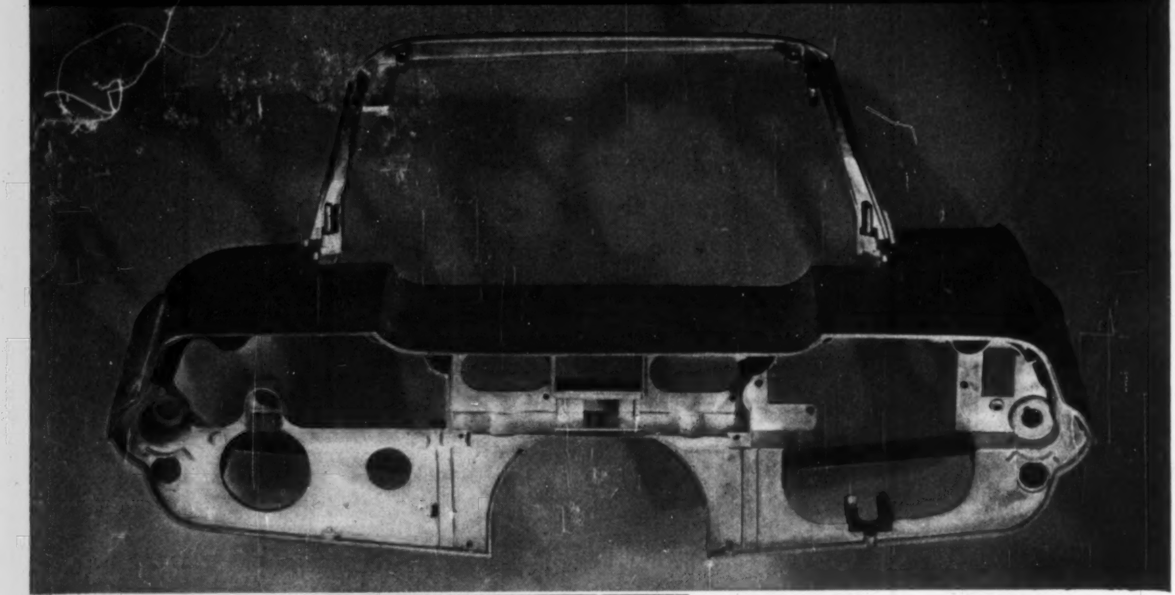
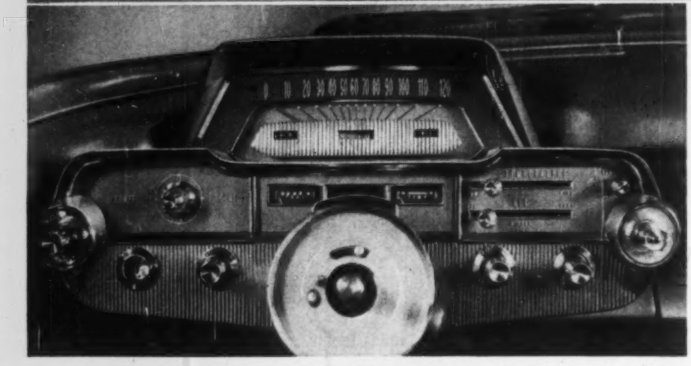
IT'S LIGHTER THAN YOU THINK!





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Materials at Work

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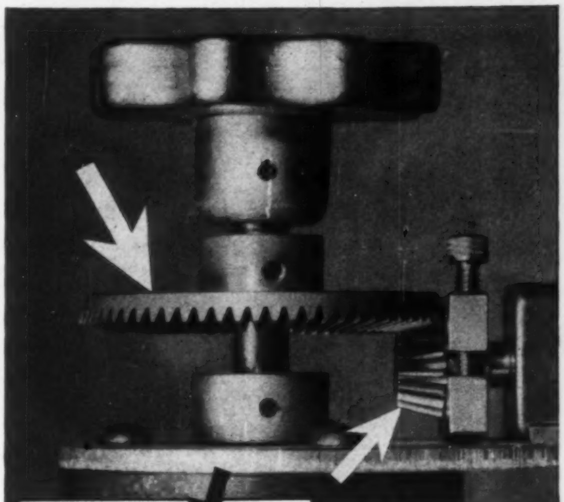
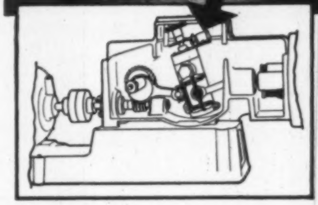
with **METAL POWDERS**





reduced
gear costs
80% for the Lapp Pulsafeeder

These mating bevel gears were formerly cut from bronze sand castings, resulting in high costs due to expensive machining, high scrap loss, and frequent rejection.

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will assist you in evaluating this modern production method in terms of your particular needs.

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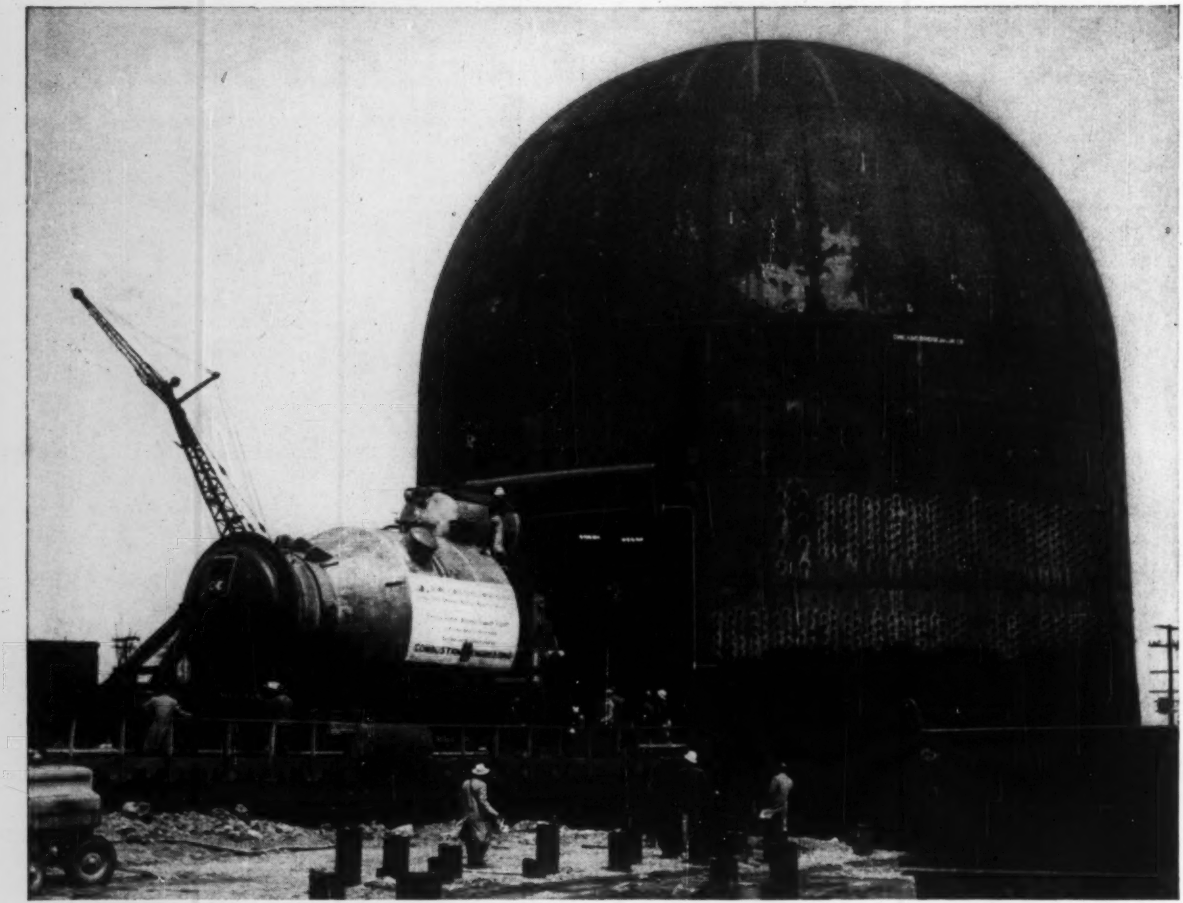

Atoms for Peace. This dome houses the 91-ton reactor vessel made of nickel-containing stainless steel for the new Enrico Fermi Atomic Power Plant on the shore of Lake Erie near Monroe, Michigan. Detail design and construction of the reactor vessel was done by Combustion Engineering, Inc. Plant will be built and operated by Power Reactor Development Company from designs supplied by Atomic Power Development Associates, Inc.

Atomic reactor "breeds" its own fuel

Stainless steel vessel must withstand high temperatures and corrosives

The world's largest full-scale nuclear reactor of the "fast-breeder" type is now being built. It may well answer the question:

> *When will atomic power be competitive with conventional methods of producing electric power?*

As the term "fast-breeder" indicates, the atom-splitting process is maintained by so-called *fast* or high-energy particles. It produces more nuclear fuel than it consumes. The fast-breeder actually turns out a kilogram and a fifth of new fuel for each kilogram it burns up!

The "breeding" takes place in a 36-foot high pressure vessel. Here, the high-energy particles (neutrons) travel at speeds of thousands of miles per second to keep the atom-splitting chain reaction going.

Accent on safety. A major objective was to make this reactor vessel safe. That called for a lot of highly specialized work.

It also called for a rugged metal: one capable of withstanding the tremendous heat given off in nuclear fission, and of bearing up under the temperatures and corrosives encountered. The final choice? Strong, corrosion-resisting Type 304 stainless steel. It's a stainless steel that contains Nickel — one of the big reasons for these superior properties.

How to "fast-breed" ideas. Problems involving reactor materials may never be a concern of yours. But you can run into *metal selection problems* involving corrosion, pressures, high temperatures and other destructive conditions almost any time. When you do, remember there is a good chance that a steel containing Nickel will provide the properties you want. Let us help you find out.

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What's new IN MATERIALS

...AT A GLANCE

A new alloy steel can be heat treated to a tensile strength of 300,000 psi. The alloy, which contains nickel, chromium, molybdenum, vanadium and boron, is designed for key aircraft and missile structural parts. Landing gear parts made of the alloy are said to have 7% more strength than comparable parts made of SAE 4340 steel. The new alloy is sold in the hot rolled or annealed condition, and is supplied in the form of bars, billets and blooms. (More details next month.)

Source: U. S. Steel Corp., 525 Wm. Penn Pl., Pittsburgh 30.

Another alloy designed for aircraft gas turbine engines has been developed. All details on composition and performance characteristics are classified at present.

Source: American-Marietta Co., 101 E. Ontario St., Chicago 11.

Fabrication of a hard, brittle magnetic material into rod, wire and strip has been accomplished by hot working. Up to now the material (Alnico 5) was considered unworkable. The new method involves vacuum melting, ingot encasing, extrusion, close temperature control, and alloy additions of zirconium, titanium and aluminum.

Source: C. L. Kolbe and D. L. Martin, General Electric Research Laboratories, Schenectady, N. Y.

An ozone-resistant Hypalon rubber-base sealant which bonds to most materials and self-cures into a resilient rubber seal is said to have a potential service life of 20 years. The new sealant is also said to retain its rubber-like properties over the temperature range –40 to 250 F. Heretofore, Hypalon rubber (chlorosulphonated polyethylene) was available for sealing applications only in the form of extrusions and sheeting.

Source: Grayguard, Inc., P. O. Box 1644, Wilmington 99, Del.

The current trend toward increasing use of refractory metals in missiles may be accelerated by the following new developments which have an excellent chance of taking place: 1) powder metallurgy dispersion-strengthened molybdenum alloys; 2) large, ductile tungsten sheet products; 3) chromium sheet products with reasonable, though not good, low temperature ductility; and 4) oxidation resistant columbium-base alloys that will meet missile and aircraft leading-edge requirements.

Source: R. I. Jaffee, Battelle Memorial Inst., Nonferrous Physical Metallurgy Div., 505 King Ave., Columbus 1, Ohio.

Large tungsten ingots weighing up to 200 lb are being made by a new "indirect sintering" technique. Blocks 8 in. in dia by 8 in. high are formed from tungsten powder in large capacity presses. The blocks are then sintered indirectly in large, high temperature furnaces and forged at high temperatures.

Source: Schwarzkopf Development Corp., 595 Madison Ave., New York City.

A new duplex nickel plating technique now joins two other duplex systems introduced last fall (see M/DE, Sept '59, p 136). In the new technique, a layer of chromium is applied over a heavy layer of semi-bright nickel and a layer of bright nickel. The developer says adhesion of the bright nickel layer to the semi-bright layer is good. Parts plated by the process have passed both the Corrodkote and

CASS (copper-accelerated salt spray) tests for corrosion resistance. (More details in a forthcoming issue.)
Source: Udylite Corp., 1651 Grand Blvd., Detroit 11.

Enamel-coated aluminum alloy sheets in widths up to 60 in. are now commercially available. Previously, enamel-coated aluminum sheets were available only in widths up to 42 in. The wider sheet can be coated on one or both sides with vinyl, vinyl-alkyd or acrylic enamels in a variety of colors.
Source: Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19.

Cleaner and structurally sounder stainless steel has been produced by using a new lithium additive that removes unwanted gases and enhances grain refinement. The lithium additive is inserted in a special steel capsule before plunging it into a charge. The technique, now used by two stainless steel producers, may be extended later to the production of mild carbon steel.
Sources: A. J. Nimeth, Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, and S. J. Myford, Copperweld Steel Co., Warren, Ohio.

Ductile polycrystalline ceramics have been produced in the laboratory by vapor depositing a small amount of silver on each grain of material before compacting. The silver apparently acts as a specific surface active agent on the individual crystals. Materials evaluated to date include sodium chloride and magnesium oxide. Thus far no ductility has been produced in polycrystalline magnesium oxide, since sintering destroys the silver deposit. (More details in a forthcoming issue.)
Source: Rpt. No. D-76, National Aeronautics and Space Administration, Washington, D. C.

High density metal parts in a wide range of shapes and sizes are possible by using a new alloy (composition not revealed) that can be cold rolled into sheet, bars, slabs and rod. Previously, high density metal parts had to be shaped by machining or molding. The new material has a 195,000 psi tensile strength and a 190,000 psi yield strength. It is suitable for radiation shielding and weights.
Source: Mallory Metallurgical Co., Div. of P. R. Mallory & Co., Inc., 3029 E. Washington St., Indianapolis 6, Ind.

Seamless vanadium tubing has been produced in experimental quantities by a new extrusion technique, details of which have not been revealed. Tubing is extruded from a new ductile form of the metal. The developer says use of the tubing as a jacketing material could possibly raise the operating temperature limit of a nuclear reactor by as much as 600 °F.
Source: Wolverine Tube Div., Calumet & Hecla, Inc., 17200 Southfield Rd., Allen Park, Mich.

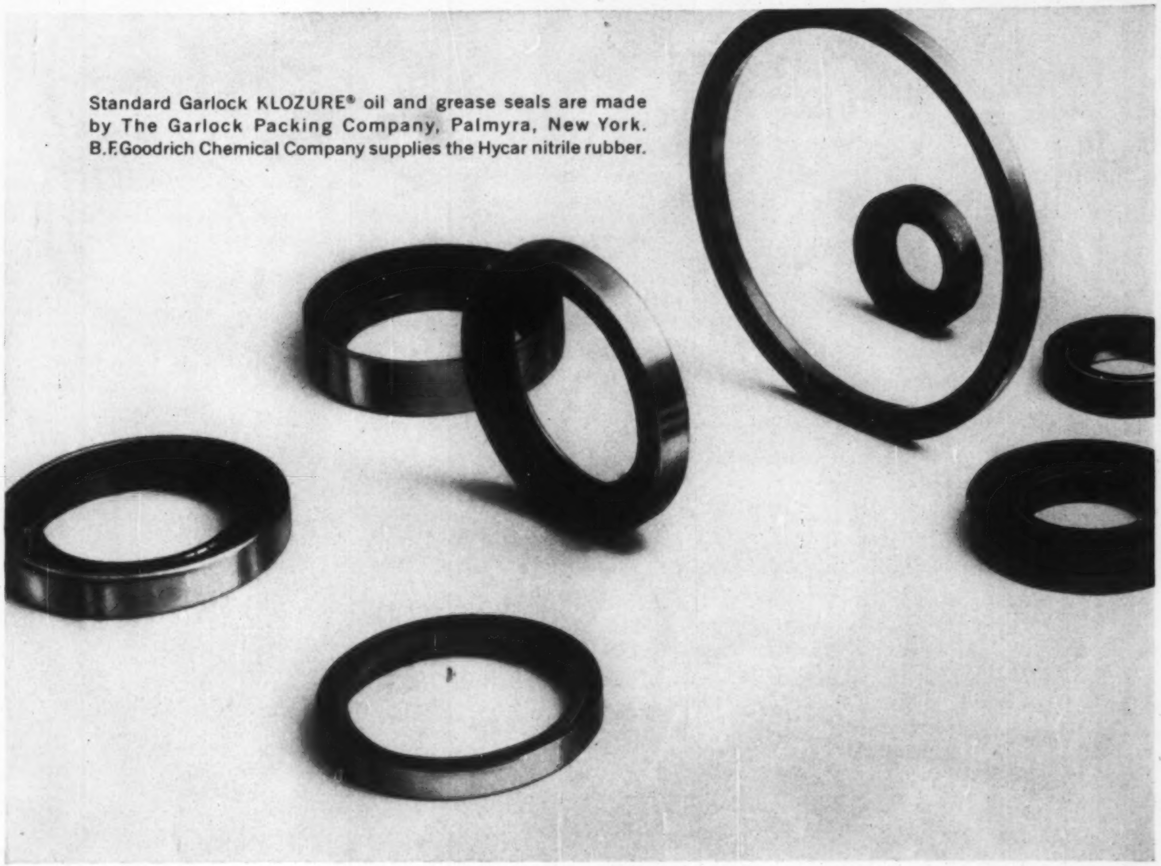
Gold-clad molybdenum stampings, now available, are designed for use as base tabs in silicon semiconductor devices. The stampings are supplied in diameters ranging from 0.030 to 0.250 in., and in thicknesses down to 0.002 in.
Source: Accurate Specialties Co., Inc., 37-11 57th St., Woodside 77, N. Y.

A substantial reduction in the shrinkage of aluminum castings has been achieved by a special refining technique which imparts shrinkage inhibition properties to the ingot. Details as to how the technique works have not been revealed.
Source: American Smelting & Refining Co., 120 Broadway, New York 5.

Turn to page 9 for more "What's New in Materials"

News about

B.F.Goodrich Chemical *raw materials*



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Here's why one manufacturer selects Hycar to make efficient, durable seals

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Further, this manufacturer likes the tough, durable and resilient qualities of Hycar. Shaft seals are abrasion-resistant, yet non-abrasive and free-running. They withstand operating temperatures from —40° F to 250° F constant, 300° intermittent.

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Photograph courtesy of Pacific Forge, Inc., Fontana, Calif.

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34

High temperature structures, *such as radomes for high speed aircraft, are likely uses for new resin.*

New High Temperature Epoxy Resin

Good for Exposure to 500 F

■ A new epoxy novolac resin promises to provide a reinforced epoxy laminate system usable for prolonged exposure at temperatures up to 500 F. Initial data indicate the resin may boost epoxy systems into the heat resistance category of TAC-polyesters and even phenolics.

Data showing residual physical properties after heat aging are scanty as yet, and limited to about 200 hr aging at 500 F. However, HDT (heat distortion temperature) values as high as 570 F have been obtained on unreinforced specimens (264 psi load). Mechanical properties obtainable are similar to those of other epoxy systems; electrical properties and chemical resistance are somewhat improved.

The new resin, designated DEN 438, was developed by Dow Chemical Co., Midland, Mich. The epoxy novolac resin differs from conventional epoxies in that it is formed by the reaction of epichlorohydrin and novolac (a phenol formaldehyde resin), rather than epichlorohydrin and bisphenol A. Although such resins have been produced before, DEN 438 resin appears to have better heat resistance than earlier epoxy novolacs.

Heat resistance

In evaluating the data shown, note the type of curing agent used. In addition to affecting final properties the curing agent also may critically affect cost, handling characteristics, and cure times.

The new resin has a high degree of reactivity to all epoxy curing agents and catalysts. It can be cured with 1) anhydrides to provide maximum heat resistance, 2) aromatic amines to provide initially high heat resistance, 3) aliphatic amines to provide good processability and room tem-

TABLE 1—COMPARATIVE HEAT DISTORTION TEMPERATURES (F)[a]

Hardener System	Postcure and/or Aging[b]	**Epoxy Novolac (DEN 438)**	Conventional Epoxies	
			DER 332	DER 331
Anhydride				
MNA[c]	24 Hr at 500 F	**570**	445	445
	72 Hr at 500 F	**510**	—	415
	120 Hr at 500 F	**495**	—	415
HET[d]	18 Hr at 350 F	**>410**	385	360
Catalytic Cure				
BF$_3$ MEA[e]	18 Hr at 350 F	**465**	320	320
	24 Hr at 500 F	**305**	0	0
	72 Hr at 500 F	**355**	0	0
	120 Hr at 500 F	**0**	0	0
Aromatic Amine				
MDA[f]	4.5 Hr at 400 F	**400**	330	310
	8 Hr at 500 F	**285**	—	212
	24 Hr at 500 F	**240**	—	0
	72 Hr at 500 F	**0**	—	0
DDS[g]	18 Hr at 350 F	**430**	375	370
Aliphatic Amine				
TETA[h]	4 Hr at 330 F	**300**	265	248

[a] ASTM D648, 264-psi load, cast unreinforced specimens.
[b] All postcures after gelling 2 hr at 200 F, or 16 hr at 75 F.
[c] Methyl nadic anhydride.
[d] HET anhydride.
[e] Boron trifluoride monoethylamine complex.
[f] p, p' methylenedianiline.
[g] 4, 4'-diaminodiphenyl sulphone.
[h] Triethylenetetramine.

perature curing characteristics, 4) polyamides to provide better flexibility, and 5) catalytic hardeners to provide good room temperature shelf life.

Table 1 shows HDT values for the new resin cured with different hardeners, and postcured and heat aged at different temperatures and times. Values for two conventional epoxies are included for comparison.

Anhydride curing agents provide the biggest improvements in HDT values—as much as 125 °F. Use of the HET anhydride, which provides flame retardance, also results in an HDT improvement of 30 °F.

Aromatic amines provide 50-80 °F improvements in HDT; aliphatic amines about 50 °F; and catalytic cures as much as 145 °F.

TABLE 2—PROPERTIES OF LAMINATES[a]

Type of Laminate ➡	High Temperature, Low Pressure Laminate[b]	Good Processing Laminate[c]
Flex Str, 1000 psi		
77 F	90	60
500 F	16.5	20.3
After 200 Hr at 500 F	31	13.9
Flex Mod of Elast, 10^6 psi		
77 F	—	2.9
500 F	2.1	2.1
After 200 Hr at 500 F	2.7	1.5
Compr Str, 100 psi		
77 F	—	33.5
500 F	11	10.9
After 200 Hr at 500 F	—	4.9
Compr Mod of Elast, 10^6 psi		
77 F	—	2.8
500 F	1.8	1.7
After 200 Hr at 500 F	—	0.8
Ten Str, 1000 psi		
77 F	—	35
500 F	—	17.4
After 200 Hr at 500 F	—	17
Ten Mod of Elast (77 F), 10^6 psi	—	2.3

[a] These initial data were obtained on laminates prepared under production conditions, and are thus not ideal data such as those taken from specimens prepared in the laboratory.

[b] 12-ply laminate laid up from 30% resin prepreg of 181 glass fabric with Volan A finish; cured 5 min at 255 F and 15 psi pressure, followed by 30 min at 375 F and 200 psi pressure; postcured 24 hr at 445 F; anhydride curing agent (MNA).

[c] 12-ply laminate laid up from 31% resin prepreg of 181 glass fabric with Volan A finish; cured 30 min at 230 F and 15 psi pressure; postcured 4.5 hr at 400 F; catalytic cure (BF_3 MEA).

In addition to improved HDT values, the epoxy novolac during test can be heated to temperatures substantially above the heat distortion temperature without the 264-psi load causing actual rupture. Conventional epoxies rupture under this stress at temperatures only slightly above their HDT. The improved internal cohesion of the DEN 438 resin is probably due to more thorough crosslinking.

Data on retention of properties after heat aging are as yet quite meager for epoxy novolacs. Table 2 shows limited data on glass cloth laminates laid up with the new resin. At present, 200 hr is the maximum aging time to which the materials have been exposed in test.

Other properties

Table 3 shows typical electrical properties of the epoxy novolac compared with those of conventional epoxies. Effects of heat on electrical properties have not been determined as yet.

DEN 438 has markedly better resistance to acetone and ethylene dichloride than conventional epoxies. In other reagents it has generally comparable chemical resistance. For maximum acid resistance, anhydride curing agents are recommended; for maximum alkali resistance, amines should be used. Of the amines, aromatic types are more acid resistant than the aliphatic.

TABLE 3—ELECTRICAL PROPERTIES[a]

Resin ➡	Epoxy Novolac (DEN 438)	Conventional Epoxy (DER 331)
Dielec Const (D150)		
Dry		
60 Cps	3.78	4.12
10^3 Cps	3.74	4.07
10^6 Cps	3.39	3.55
Wet (24 hr, water)		
60 Cps	3.82	4.19
10^3 Cps	3.80	4.15
10^6 Cps	3.44	3.61
Dissip Factor (D669)		
Dry		
60 Cps	0.0027	0.0035
10^3 Cps	0.012	0.015
10^6 Cps	0.024	0.032
Wet (24 hr, water)		
60 Cps	0.0021	0.0043
10^3 Cps	0.012	0.016
10^6 Cps	0.025	0.032
Vol Res (D257), ohm-cm[b]		
Dry	0.380×10^{16}	0.181×10^{16}
Wet (24 hr, water)	0.183×10^{15}	0.231×10^{15}

[a] Both resins cured with an aromatic amine (MDA); epoxy novolac cured 1 hr at 200 F, postcured for 16 hr at 350 F; conventional epoxy cured 16 hr at 77 F, postcured 4.5 hr at 330 F.

[b] 1-min electrification; 500 v d.c.

Potential applications

Initial uses for DEN 438 resin will be in glass-reinforced laminates where elevated temperature strength is required. Such uses would include aircraft structures, plastics tooling, reinforced plastics pipe, printed circuit board, and various electrical insulating uses.

The high viscosity of the new resin will probably make it most widely used in the form of preimpregnated laminates. Such laminates can be supplied either quite dry or with substantial tack, depending on handling requirements.

The resin can be fabricated by wet layup techniques, but relatively low-viscosity curing agents such as some anhydrides must be used. Aromatic amines may be used in some cases where the resin can be heated slightly to reduce viscosity prior to mixing and using.

The new resin is promising for high temperature protective coatings and adhesives. Potential types of coatings include partial esters, amine-cured solution coatings, high solids coatings, and fluidized bed formulations.

Some adhesives formulated with the new resin are already available. They are reported to show good retention of properties at temperatures as high as 500 F, and as low as -65 F. Both tape-supported and liquid adhesive systems can be made by simple substitution of DEN 438 for conventional epoxies in adhesive formulations.

For more information, circle No. 600

AWARDS COMPETITION — Are you working on your entry for M/DE's fourth annual Awards Competition? See p 138 for full details.

New Heat Treating Process

Raises Strength
Keeps Ductility

■ A new heat treating process recently developed on the West Coast is increasing the yield strength of a considerable number of high strength materials as much as 35%, according to its developers, Research Development Corp. of America. The accompanying table compares some of the claims of the RDCA process with results obtained by conventional heat treating techniques. The details of the process are not available for publication pending patent clarification.

The most important advantage of the process is the increase in strength without sacrifice of ductility. Although no tests have been made to show the effects of the RDCA process on impact strength or ductile-to-brittle transition temperature, the results obtained with other mechanical properties would indicate that there is no deleterious effect and that, in fact, some improvement may be expected. Therefore, the accepted pairing of high strength with low ductility and low impact strength may no longer be realistic.

Other advantages claimed by the developers of the process include: 1) reduction of residual stresses, 2) elimination of size effect, 3) elimination of grain growth in martensitic alloys, 4) reproducibility of structure and properties, 5) increased resistance to crack propagation and reduced notch sensitivity, and 6) elimination of composition sensitivity.

Distortion after heat treatment, it is claimed, is held to 0.0002-0.0003 in. per in.

COMPARISON OF MECHANICAL PROPERTIES
(Standard Heat Treatment vs RDCA Process)

Alloy ↓	Ten Str, 1000 psi		Yld Str, 1000 psi		Elong, %		Red. of Area, %	
	Std	RDCA	Std	RDCA	Std	RDCA	Std	RDCA
4037	200	280	165	265	8	11	35	35
4130	235	250	220	230	10	13	40	64
4140	290	325	252	305	11	12	42	32
4340	283	334	228	312	11	11	38	32
6150 (0.53% C)	280	383	245	339	9	8	42	25
6152 (0.49% C)	280	361	310	315	9	9	38	27
Thermold J, Unimac #2	317	354	263	290	4.8	7	14.7	22
Vascojet 1000, Unimac #1	311	328	241	309	4	13	7	37
Venango Special	358	418	325	352	6	8	24	21
410 Stainless Steel	200	222	180	205	2	12	4	36
431 Stainless Steel	190	242	155	180	14	17	50	57

For more information, circle No. 601

Beryllium Nickel Casting Alloys

■ Two beryllium nickel casting alloys were recently introduced by Brush Beryllium Co. at the Metals Show in Chicago. The alloys are of interest because of their excellent castability, high strength, hardness and good corrosion resistance. They can be cast by various techniques including sand casting, investment casting and permanent mold casting.

Some uses of the new beryllium nickel compositions include turbine wheels, glass molds, plastic compression molds, textile needles, valve bodies, wrench drills and fuel injection tips.

The following analyses (%) are available:

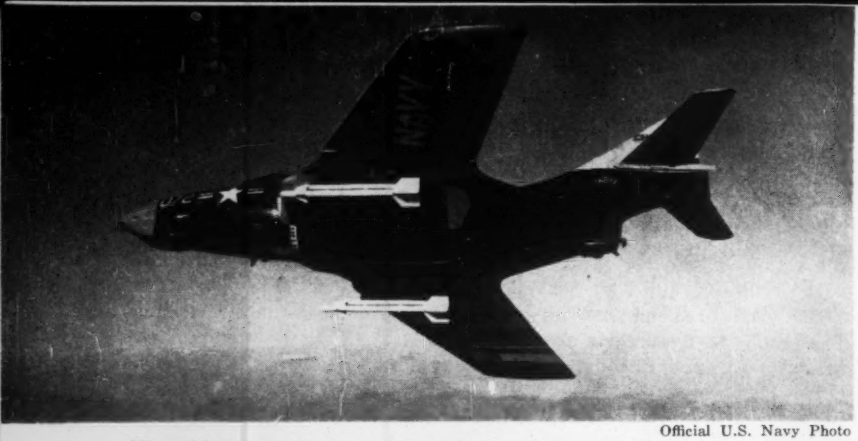
Alloy	Be	C (max)	Ni
220-C	2.00-2.30	0.40	Bal.
260-C	2.55-2.80	0.40	Bal.

Typical properties are given in the accompanying table for the 260-C alloy. The reduction of beryllium content in the 220-C alloy leads to a moderate decrease in hardness and strength, but improves machinability. Both alloys are magnetic and provide excellent resistance to elevated temperatures (up to 700-800 F).

TYPICAL PROPERTIES OF
BE-NI CASTING ALLOY 260-C

Condition ➡	Cast	Cast and Soln Ann.	Cast, Soln Ann. and Aged
PHYSICAL PROPERTIES			
Elec Cond, % IACS	3-7	2-6	4-9
Coef of Ther Exp (avg 68-392 F), 10^{-6} per °F	7.7	7.7	7.7
MECHANICAL PROPERTIES			
Hardness, Rockwell C	24-30	20-25	52-56
Yld Str (0.2% offset), 1000 psi	60-70	50-65	190-210
Ult Ten Str, 1000 psi	115-125	90-100	200-220
Elong (2 in.), %	7-12	8-15	0-2
Red. of Area, %	5-10	10-15	0-1
Izod Impact Str, ft-lb	20-25	90-100	10-15
Elastic Modulus, 10^6 psi	27	27	27

For more information, circle No. 602



Official U.S. Navy Photo

IR guidance systems, *such as that used on the Navy Sidewinder missile, can be improved by use of crystals such as strontium titanate to focus IR energy and increase gain.*

Three New Single Crystal Materials

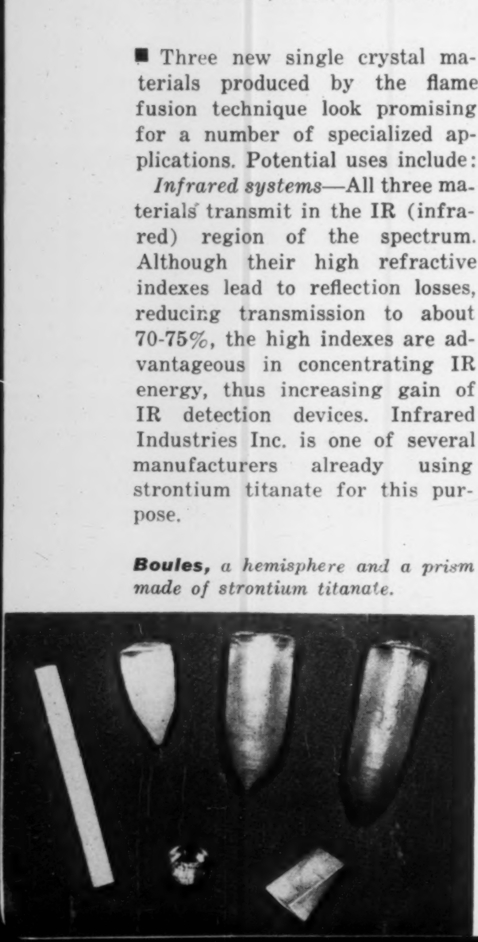
Strontium Titanate • Calcium Titanate • Rutile hold promise for optical and electronic applications

by M. D. Beals and L. Merker, *Research Laboratory, Titanium Div., National Lead Co.*

■ Three new single crystal materials produced by the flame fusion technique look promising for a number of specialized applications. Potential uses include:

Infrared systems—All three materials transmit in the IR (infrared) region of the spectrum. Although their high refractive indexes lead to reflection losses, reducing transmission to about 70-75%, the high indexes are advantageous in concentrating IR energy, thus increasing gain of IR detection devices. Infrared Industries Inc. is one of several manufacturers already using strontium titanate for this purpose.

Boules, *a hemisphere and a prism made of strontium titanate.*



Ultraviolet filters—The sharp cutoff of strontium titanate at the ultraviolet end of the visible spectrum indicates its suitability as an efficient ultraviolet light filter.

Microwave amplification—Recent work by ***Müller*** indicates that strontium titanate may be a satisfactory host lattice to which additions of specific impurities could be made to produce a desired response to an applied electric or magnetic field. The crystal structure and the high specific resistivity ($>10^9$ ohm-cm) also should be useful characteristics. For example, strontium titanate may be useful in solid state devices such as a microwave amplifier (maser).

Gem stones—Both rutile (titanium dioxide) and strontium titanate have been used as gem stones of high brilliance and fire. Strontium titanate is preferred because in addition to its high refractive index it is colorless and optically isotropic.

Comparison of properties

The three single crystal materials are produced in the form of carrot-shaped boules by the flame fusion technique. Size of boules at present is limited to 1 in. in dia and 2 to 3 in. long.

Transmission characteristics of the three materials are shown in Fig 1. The materials are transparent, with high indexes of refraction, as shown in Fig 2. Other properties are given in the accompanying table. The materials are hard (600-750 Knoop), resistant to high temperatures (melting points are from 3300 to 3775 F), and chemically durable. Strontium titanate is relatively expensive, costing about $1 per carat (0.2 gm); rutile costs about 50¢ per carat. Calcium titanate, the newest of the materials is not yet commercially available.

Titanates

Strontium titanate is optically isotropic. It is a cubic crystal; consequently its optical properties are not a function of orientation, and it looks like glass. It has a high dispersion (change of index with wavelength, n_F-n_C) of 0.108, with a reciprocal relative dispersion ν) of 13 (ν calculated from n_D- $1/n_F$-n_C); thus the lower the value for ν, the higher the dispersion. For comparison, diamond and a high-dispersion heavy flint glass have ν values of 56 and 30, respectively.

Strontium titanate has a relatively high refractive index, as shown in Fig 2. Though no index is shown for the infrared region, a reasonably high index can be inferred from the flattening of the curve as wavelength increases.

Room temperature dielectric constant is 310 at 100 kc; loss angle is a relatively low 0.0003.

No evidence of ferroelectric behavior such as that found in barium titanate has been discovered in strontium titanate. But the material does appear to undergo a phase transition from cubic to tetragonal at about −292 F. The tetragonal phase, however, is nonferroelectric.

Color, in shades ranging from amber to red or a dark blue, can be induced by adding impurities, followed by stabilization.

Calcium titanate, boules of which have also been grown by the flame fusion technique, appears to be somewhat comparable in properties to strontium titanate (see table). It transmits to a somewhat shorter wavelength in the ultraviolet (see Fig 1), has a slightly lower melting point of 3600 F, and is about comparable in hardness. It has a refractive index only slightly lower than that of strontium titanate with a similar dispersion. However, it crystallizes in the orthorhombic system and thus is not optically isotropic.

Rutile

Perhaps the most striking property of single crystal rutile, marketed first in 1949 by National Lead, is its high index of refraction for both ordinary and extraordinary rays (see Fig 2). The rapid increase in index with decrease in wavelength leads to a high dispersion of 0.16 for the ordinary, 0.20 for the extraordinary, ray. A comparable value for diamond would be 0.025. Rutile's reciprocal relative dispersions (ν) are 10 and 9, respectively, for the ordinary and extraordinary ray.

Rutile has an absorption edge at about 0.420 μ; thus sufficient blue light is absorbed to give the crystal a slight yellow-green cast. Rutile also has a strong birefringence (variation in refractive index with orientation).

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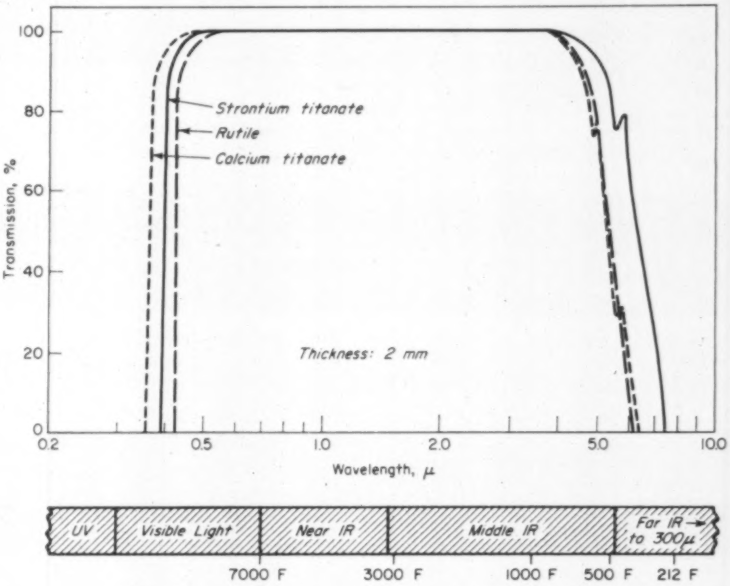


Fig 1—*Transmission of strontium and calcium titanates and rutile, corrected for reflection loss. Loss reduces actual transmission to 70-75%. Temperature values indicate wavelength at which peak IR radiation occurs from a black body at that temperature, e.g., peak radiation of a black body at 7000 F occurs at wavelength of 0.7 μ.*

PHYSICAL PROPERTIES OF THREE SINGLE CRYSTALS

Material ➡	Strontium Titanate	Calcium Titanate	Rutile
Crystal System	Cubic	Orthorhombic	Tetragonal
Unit Cell Size, Angstroms			
a_o	3.90	—	4.58
c_o	—	—	2.95
Specific Gravity	5.13	4.05	4.26
Knoop Hardness	600-650	600-650	650-750
Melting Point, F	3775	3580	3300
Index of Refraction (n_D)			
Ordinary Ray	2.409	2.41	2.613
Extraordinary Ray	—	—	2.909
Dispersion (n_F-n_C)			
Ordinary Ray	0.108	0.09	0.164
Extraordinary Ray	—	—	0.207
Reciprocal Relative Dispersion (ν)			
Ordinary Ray	13	16	10
Extraordinary Ray	—	—	9
Transmission Range, μ	0.395-6.2	0.365-5.3	0.420-5.3
Dielectric Constant (100 kc)	310	200	190[a]
Loss Angle (100 kc)	0.0003	0.001	0.017[a]

[a] Parallel to c-axis.

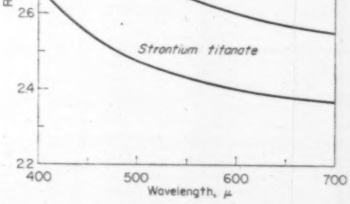


Fig 2—*Refractive index over visible light spectrum.*

For more information, circle No. 603

Continuous Compaction:

A New Process for Metal or Ceramic Powders

■ The advantages to be gained in forming large sections by means of powder metallurgy techniques have not been fully exploited because of limitations in current fabricating methods. Except for the direct rolling of metal powders, no method has been described for the continuous formation of solids from powders.

A technique recently developed at the Materials Engineering Dept., Westinghouse Electric Corp. by F. Emley and C. Deibel allows the production of powder metal bars of unlimited length and relatively large cross-sectional area. The method is called Continuous Compaction and is shown schematically in Fig 1. Loose powder (A) is placed in a three-sided trough (B-C). The powder is compressed by the punch (D) which consists of a flat pressing surface parallel to the powder surface and a pressing surface angled to the powder surface. The two punch surfaces are faired together.

Fig 2 illustrates the sequence of events during pressing and essentially describes the major features of the continuous compaction process. It is a process

(continued on p 159)

Fig 1—Schematic view of continuous compaction set-up.

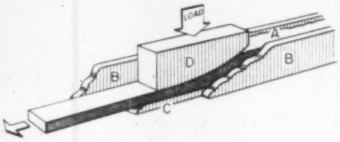
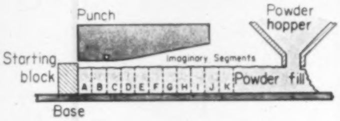
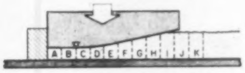


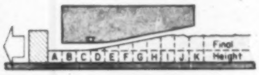
Fig 2—Sequence of continuous compaction operations.



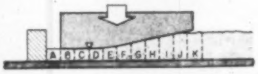
1. Punch is clear *of pressing area and loose powder is charged into die. Starting block forms end of bar. Loose powder is shown divided into series of imaginary segments A-K.*



2. First pressing operation. *Finishing area (flat surface) of punch presses segments A and B. Curved portion applies varying pressure to other segments.*

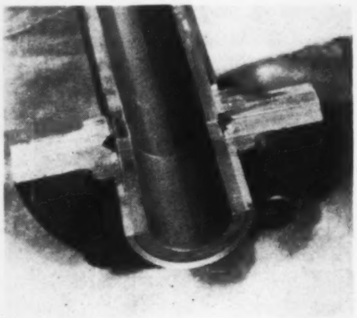


3. Punch is raised *and die advanced to bring segment C under finishing area.*



4. Pressing cycle is repeated *until desired length of bar is formed.*

Chlorinated polyether-lined pipe—Shown at right is what is claimed to be the first commercially available steel and aluminum pipe lined with chlorinated polyether. Also available for the first time are fittings lined with chlorinated polyether, and injection molded chlorinated polyether pipe and fittings. The producer, Tube Turns Plastics, Inc., 2929 Magazine St., Louisville 11, Ky., says the pipe and fittings should find use in piping hot corrosive fluids. Chlorinated polyether is produced by Hercules Powder Co. **KEY NO. 627**



MORE WHAT'S NEW IN MATERIALS

Six organic coatings for metal products..... 160
Closed-die forgings 167
Phenolic-graphite withstands 5000 F 168
Two more materials for high temperatures 170
Refining technique may cut price of titanium... 172
Other news 174

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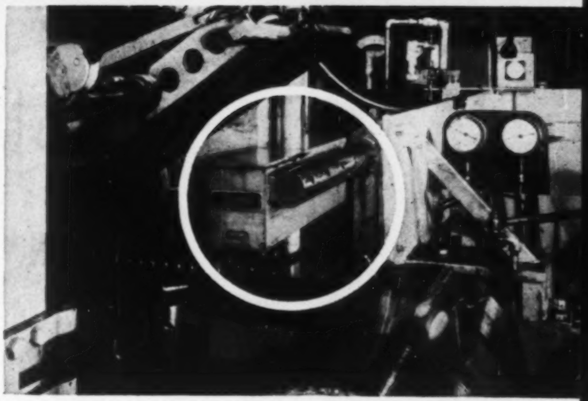

Typical of J&L precise control is this AccuRay thickness gauge to help assure tolerances on cold rolled strip steels.

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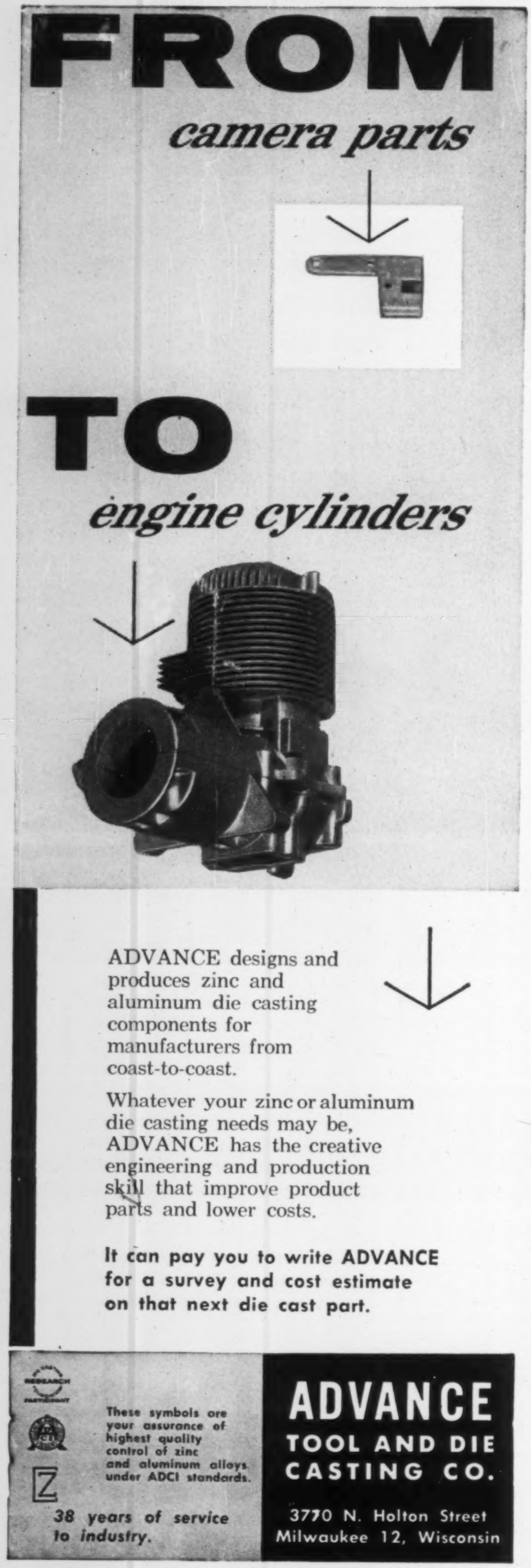

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Letters to the Editor

Vacuum melted alloys

To the Editor:

This is to compliment you on the feature article, "Vacuum Melted Metals and Alloys," Aug '59, p 89. You have done a fine job of summarizing the advantages of and uses for various vacuum melted materials, and your article should be a big help in properly orienting the design engineer.

However, I would like to comment on one portion of your article. On p 93 you state that ". . . properties of vacuum melted alloys should be similar regardless of which method is used in producing them . . ." Our data indicate that there are differences according to the vacuum melting method used, and we have classified these into three categories, namely properties that are 1) chemistry-sensitive, 2) segregation-sensitive, and 3) cleanliness-sensitive.

Induction vacuum melting seems to offer the best results in alloys which fall into the first category, consumable electrode in alloys which fall into the second category, whereas both processes produce similar results in the third category. I am including a copy of a recent paper presented at the Western Metals Conference of ASM, which treats these points in greater detail.

W. W. DYRKACZ
Manager of Quality
Allegheny Ludlum Steel Corp.
Watervliet, N. Y.

Plastics cone molder?

To the Editor:

We would like to contact a molder to produce a plastics cone measuring approximately 8 in. long by 4⅝ in. in dia at the large end by 1 in. in dia at the small end. The cone can be made of a thermoplastic material, and can have a hole in the pointed end. We desire to cement a 1-in. o. d. plastics tube onto the end of the cone to make a toy.

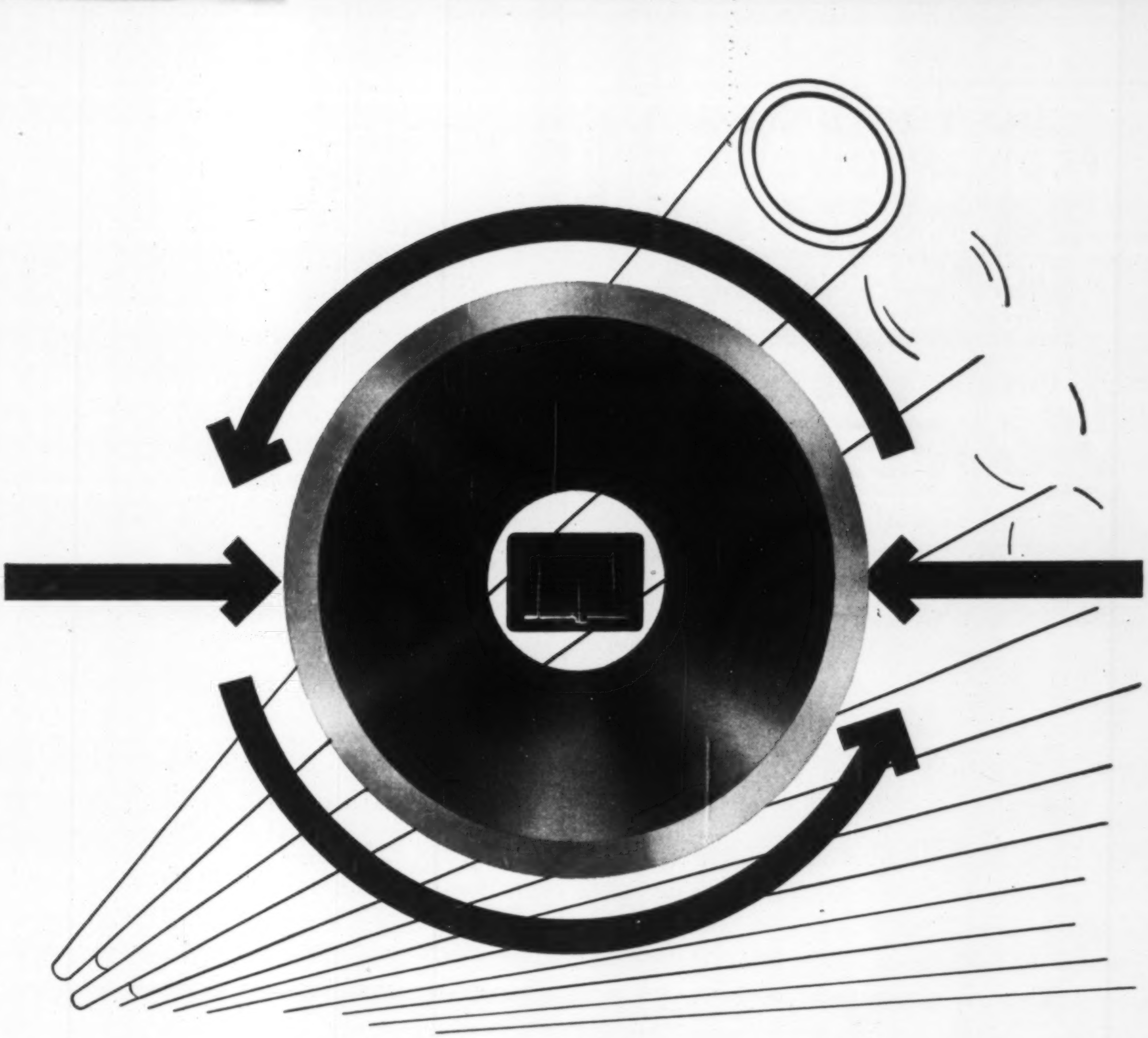
MELVIN E. SEYMOUR
Veg-A-Peel Co., Inc.
215-219 N. Walnut St.
Creston, Iowa

Safety second

To the Editor:

In connection with the manual, "Organic Coatings for Metal Products," Mar '59, you published a picture of three men coating a tank car. This could better have been labeled "What not to do," or "A safety man's nightmare."

In the first place, the man doing the spraying has neither mask nor goggles. Also, he has a rag hanging out of his pocket which could catch and cause him to lose his balance, especially dangerous when working on a narrow platform. Further, one



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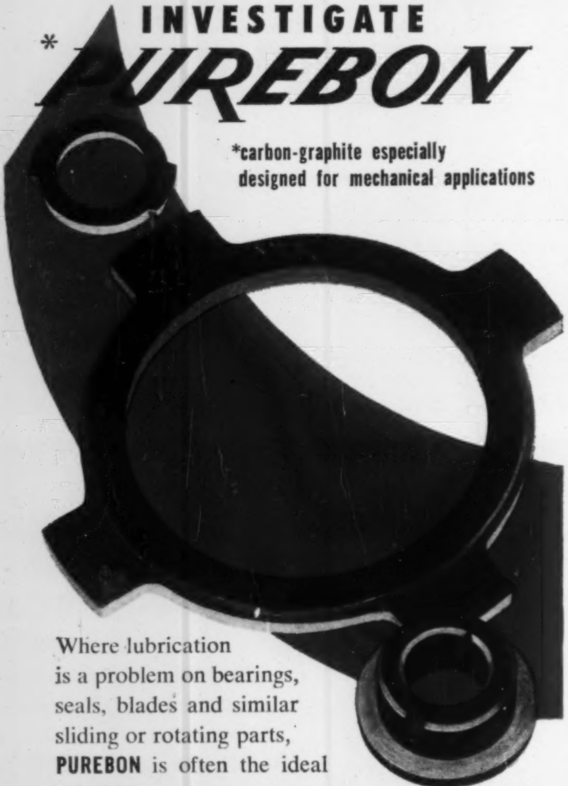

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Letters to the Editor

of the men standing on the floor is smoking a cigarette. This should not be allowed within several feet of any spray painting operation. In addition, the floor is littered with rubbish and boards, and the hose lines are spread out to cause a real hazard to anybody working in the area.

Perhaps they are using an emulsion which would excuse the man who is smoking, but the other points can only be called unsafe and dangerous.

SAMUEL E. SAUNDERS
Roslindale, Mass.

Nondestructive bond tester

To the Editor:

The article "Adhesive Bonding of Titanium," Feb '59, p 96, has been read here with great interest. It is an excellent survey of the problems and progress in this field.

We should like to comment, however, on the statement that one disadvantage is the lack of nondestructive testing procedures. We would like to bring our Fokker Bond Tester to your attention.

This instrument is a nondestructive unit which has proven its reliability in testing both metal-to-metal and metal-to-core bonded joints. One of the most successful operations of the Fokker Bond Tester was its use in conjunction with the inspection and repair of the Sikorsky rotor blades shown in the photographs on p 96.

R. J. SCHLIEKELMANN
N. V. Koninklijke Nederlandse
Vliegtuigenfabriek Fokker
Schiphol-Zuid, The Netherlands

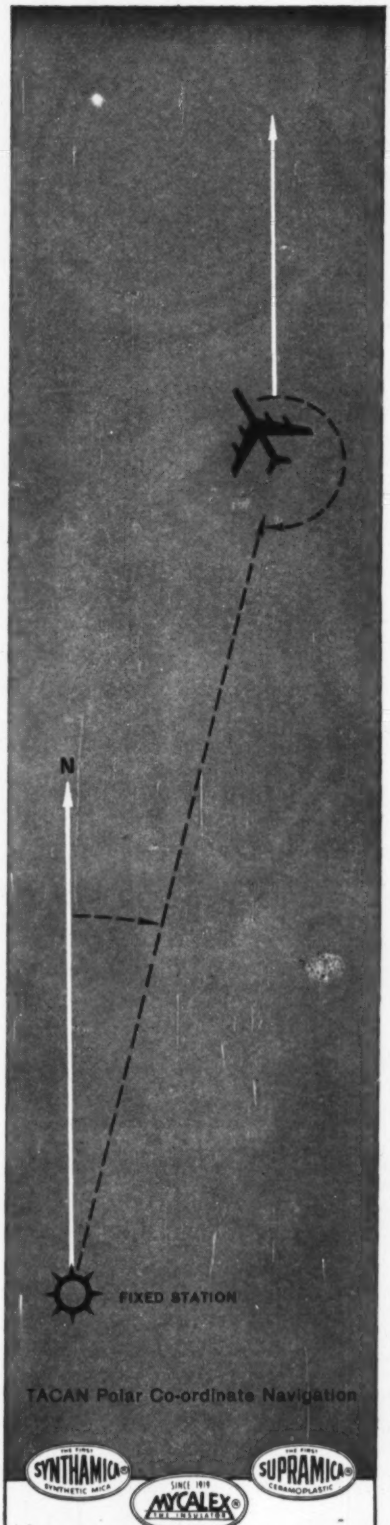
Abrasion resistance

To the Editor:

We have noticed numerous references in your magazine to abrasion resistance properties of various materials. A typical example is the abrasion resistance of Code 9605 Pyroceram brand polycrystalline glass which is listed as 27 (M/DE, May '58, p 121). What is the standard procedure for determining this data? Is it similar to the method outlined in the 1948 issue of Metals Handbook for determining abrasion resistance of metal against nonmetal or abrasive? Do you know of any published data which directly compares the abrasion resistance of both metallic and nonmetallic materials on a common basis, or is such a comparison not valid?

R. E. PIERSON
Corn Products Co.
Argo, Ill.

Abrasion resistance depends on many variables and there are no standard tests. Hard Surfacing by Fusion Welding, *American Brake Shoe, 1947, discusses various methods of testing for abrasion resistance.*



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"gives high impact strength . . . superior insulating value," in ITT's TACAN beacon

Latest achievement in air navigation and traffic control is TACAN, an advanced radio air navigation system developed by ITT Laboratories, Division of International Telephone and Telegraph Corporation, for the U. S. Navy and Air Force.

Prominently featured in the 12 KV discharge switch of TACAN's ground beacon transmitter is MYCALEX 410 glass-bonded mica insulation. Here and in other applications, this precision-molded insulation shows exceptional mechanical strength and superior electrical resistance. It will withstand operating temperatures to +600°F . . . and has *total dimensional stability!*

Why was MYCALEX designed into this item? Says ITT: "*MYCALEX was selected because of its high impact strength and excellent insulating properties, which we found to be as good as or better than grade L-4B in ceramic. In addition, the good molding properties of MYCALEX made it possible to design the insulator with convolutions which increased the creepage path to ground.*"

MYCALEX 410 is one of a wide variety of glass-bonded mica and ceramoplastic insulation materials created and perfected by Mycalex Corporation of America. Whatever insulation characteristics you require, there is a Mycalex material to meet your need. For example, SUPRAMICA® 560 precision-molded ceramoplastic offers a maximum operating temperature of +932°F . . . and SUPRAMICA 620 machinable ceramoplastic offers a maximum operating temperature of +1550°F. Write today for specifics.

General Offices and Plant: 122K Clifton Blvd., Clifton, N. J.
Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.

MYCALEX
CORPORATION OF AMERICA

WORLD'S LARGEST MANUFACTURER OF GLASS-BONDED MICA AND CERAMOPLASTIC PRODUCTS

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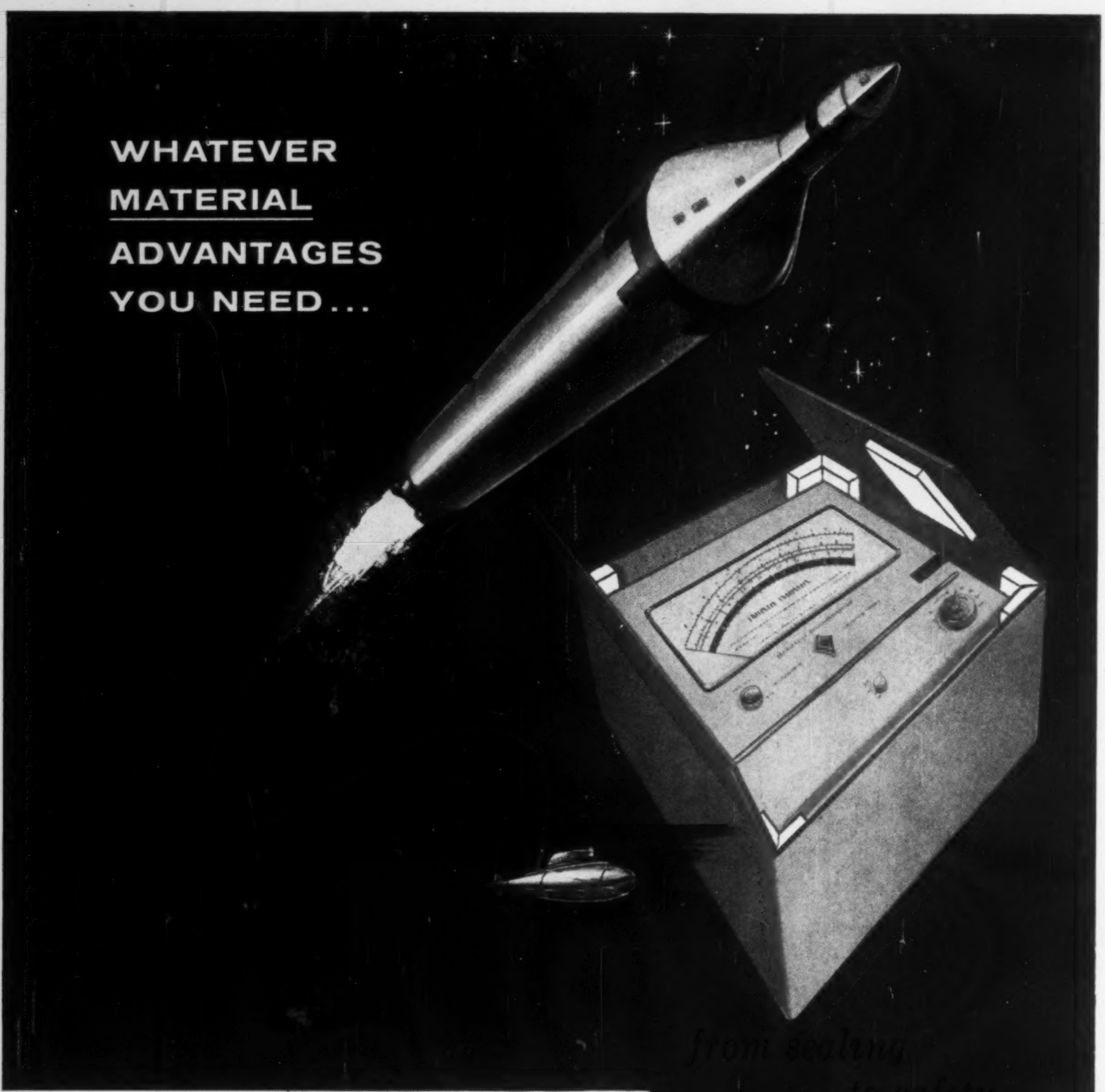

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Versatile A+ FELTS . . . *precision engineered* to meet your *exact* design specifications . . . have over a thousand different uses. They form the tight-sealing packing and gaskets essential to reliable missile performance . . . and insure the safe shipment of delicate instruments by cushioning them against shock and vibration. In other forms, they filter . . . insulate . . . polish . . . absorb . . . and set new standards in fashion.

Find out how A+ Felts can improve *your* application by sending us your design problem. Our engineers will follow through promptly. Write: Engineering Dept., American Felt Company, 401 Glenville Road, Glenville, Conn.

Among our famous trademarks: **VISTEX**—fiber-reinforced gaskets and seals; **WINDSOR FELT**—nonwoven bonded fabrics; **HUSHALON**—decorative and acoustical wall covering.

American Felt Company

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PRICES & SUPPLY

. . . AT A GLANCE

Price of aluminum goes up. Aluminum Co. of America recently increased the price of primary pig aluminum from 25 to 26¢ per lb. The price action has been followed by other U. S. producers. At the same time . . .

Look for slightly higher prices on most other nonferrous metals this year, says the Bureau of National Affairs, Inc. in its annual forecast for 1960. The Bureau says more aluminum, copper, nickel, tin and lead will be used in 1960 than in 1959. Use of lead in cable sheathing will decline, but rises are seen in vibration absorption, sound attenuation, and radioactive shielding. Use of zinc will increase 8 to 10% in 1960, the increase centering in die casting.

A new source for man-made industrial diamonds will be De Beers Consolidated Mines, Ltd. Diamonds will be made by a high pressure technique similar to the one now used by GE for producing diamonds (see *Materials & Methods*, Apr '55, p 12, and M/DE, Dec '57, p 178). De Beers' diamonds, though not now commercially available, will probably compete with GE's man-made diamonds for a number of applications. Current price for man-made diamonds is $2.74 per carat.

Extremely pure nonferrous metals for electronic and other applications will soon be available from a new company—High Purity Metals, Inc., 340 Hudson St., Hackensack, N. J. The company will specialize in the production of tin, aluminum, germanium, lead, gallium and indium. The metals will be supplied in the form of ingots.

Price of a major ingredient used in urethane foams has been cut. According to the Silicones Div., Union Carbide Corp., price of organo-silicone copolymer surfactants has been reduced from $2.80 to $2.56 per lb.

Price of a relatively new all-beta titanium alloy, B-120VCA, has been cut by Crucible Steel Co. of America. Base price of billets is now $4.75 per lb, down $1 per lb; strip $14.40, down $1.25; bar $6.25, down $1.25; sheet $15.50, down $1.50; and wire $8.50, down $1.50. The alloy, introduced in the fall of 1958 (see M/DE, Sept '58, p 131), can be heat treated to a tensile strength of 240,000 psi.

Price cuts on a line of reinforced polyester molding compounds and an increase in the number of colors available have been announced by Hercules Powder Co. The largest price cut (9¢ per lb) has been made on Thermaflow 800, a glass-reinforced molding compound.

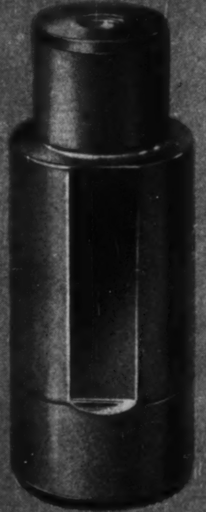
Increased production of polyvinyl alcohol resins has been announced by Shawinigan Resins Corp. According to the company, expanded facilities will permit a 100% increase in production of standard grades. The expansion will also permit greater diversification into specialty grades of PVA resins. The material is used in the manufacture of adhesives, films, textiles and paper.

two more cases where **PARTS PRODUCED FROM provide excellent bearing properties**

CASE HISTORY

MUELLER BRASS CO. 600 ALLOY screw machine product used in heavy duty farm equipment

This heavy duty planetary pinion shaft, made as a screw part from tough "600" series bearing alloy, was the answer to a continuing wear problem encountered in the driving mechanism of heavy-duty farm equipment and big trucks. The part is machine produced to exacting tolerances and all necessary finishing operations are done by Mueller Brass Co. so the pinion shaft is ready for installation when received. Since "600" alloy parts have been installed, no operating failures have been reported and the shafts have proved far superior to the material formerly used.



MUELLER BRASS CO. ANALYSIS SERVICE

You get sound, unbiased advice on the one best method of making your parts because Mueller Brass Co. is the only fabricator in the country offering all these methods of production. An experienced Methods Analysis Department has at its command a complete knowledge of the advantages and limitations of each production process. This unique technical service is your assurance of getting the best product at the best price . . . made the one best way!

COLD-PREST IMPACT EXTRUSIONS

PLASTIC INJECTION MOLDING

MUELLER BRASS CO.

MUELLER BRASS CO. 600 ALLOY

and maximum wear resistance in tough applications

CASE HISTORY

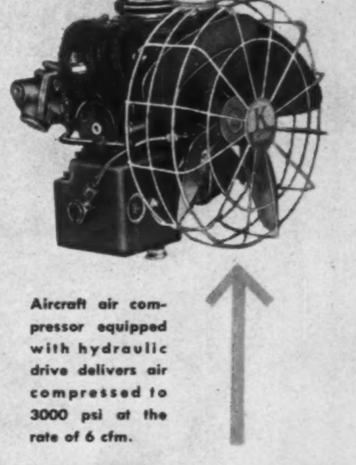
MUELLER BRASS CO. 600 ALLOY forgings used in aviation air compressors

Analyzing the job requirements of Walter Kidde & Company, Inc., for a main driving cam component to be installed in a reciprocating type of aircraft air compressor, Mueller Brass Co. Methods Analysis Engineers decided on a forging fabricated from "600" alloy as the most practical method of production. Since the cam forms the prime component of the driving mechanism, it must have good bearing wear surfaces and because the compressors are used in the aviation industry, the cams must be completely dependable. The close grained, strong forging that resists combination compressive and tensile stresses was the answer.

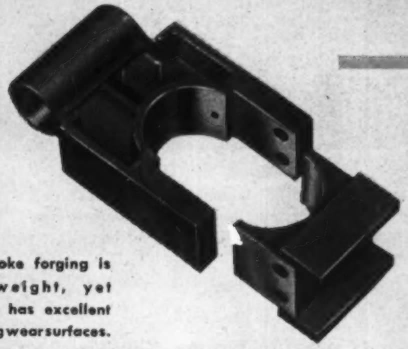
A typical compressor takes in ambient air and compresses it to 3000 psi or higher. This high pressure air is stored in metal or fiberglas containers until needed for actuation of pneumatic system components such as solenoid control valves, brake valves, manual control valves or actuators. These and other pneumatic units retract the entrance door, operate landing gear, wheel brakes, nose wheel steering systems, propeller brakes or perform other functions.

Aircraft in which Kidde compressors are installed include the Boeing 707, the Douglas DC-8, the Lockheed Electra, the Fairchild F-27 and various military aircraft.

Mueller Brass Co. produces press, hammer or cored forgings of any practical shape from a few ounces to 150 lbs. in brass, bronze, aluminum and magnesium in 27 standard, as well as special, alloys.



Aircraft air compressor equipped with hydraulic drive delivers air compressed to 3000 psi at the rate of 6 cfm.

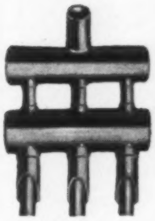


This yoke forging is lightweight, yet strong; has excellent bearing wear surfaces.

Forging is part of the main cam, the prime component of a modified Scotch-type yoke, which is the piston driving mechanism in the air compressor.

POWDERED METAL PARTS

SAND CASTINGS



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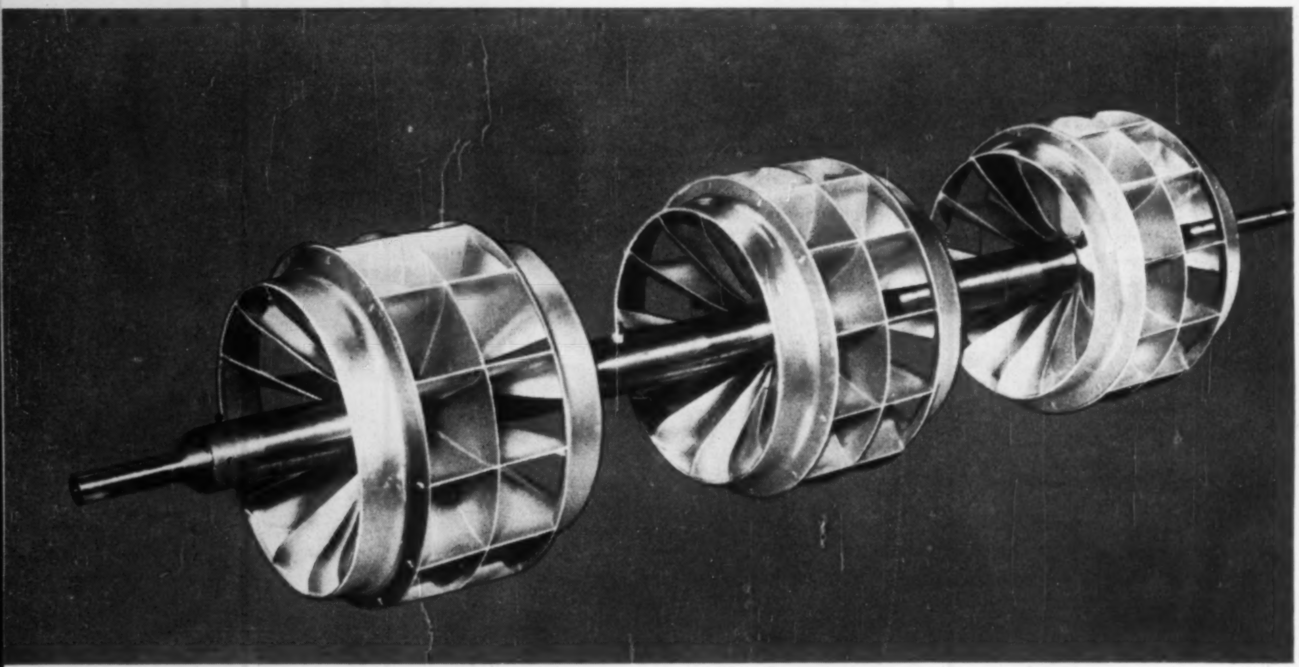
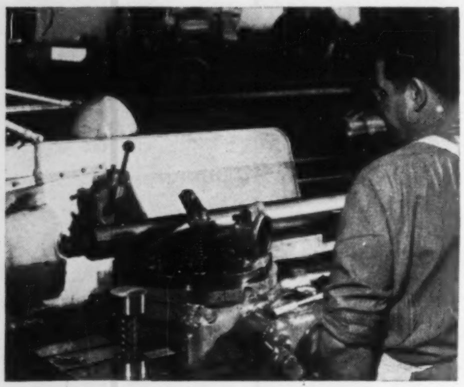
TRULY CONCENTRIC ELECTRUNITE MECHANICAL TUBING ELIMINATES ROTOR SHAFT MACHINING



SCROLL-TYPE BLOWERS up to 27″ in diameter are mounted on ELECTRUNITE shafts, some up to 94″ long, and designed to operate at approximately 1,110 rpm. Careful balance and uniformity of the tubing is required for high operating efficiency.



DUE TO THE UNIFORM CONCENTRICITY of Republic ELECTRUNITE Mechanical Tubing, no machining is required in producing air conditioning rotor shafts at Buffalo Forge Company. Rotor shafts are bored at each end and plug inserted for the bearing. Because of the uniformity of ELECTRUNITE, only .015 of the stock is removed before the plug is pressed into the tubing ends.

Buffalo Forge Company, Buffalo, New York, saves valuable machining time by using Republic ELECTRUNITE® Mechanical Tubing in manufacturing air conditioning and ventilating units. ELECTRUNITE in sizes of 3″ to 3¼″ O.D., 8-gage, is used as shafting for the rotors of the blower system.

Scroll-type blowers up to 27″ in diameter are mounted on ELECTRUNITE shafts, some up to 94″ long, and designed to operate at approximately 1,110 rpm. Small shafting will turn at 2,300 rpm. True concentricity of ELECTRUNITE is vital to high operating efficiency of these units due to the careful balance required in relation to the high rpm and weight involved.

Republic ELECTRUNITE Tubing, carbon or stainless, may solve your particular production or cost problems, too. Call your Republic representative, or write direct.

1.

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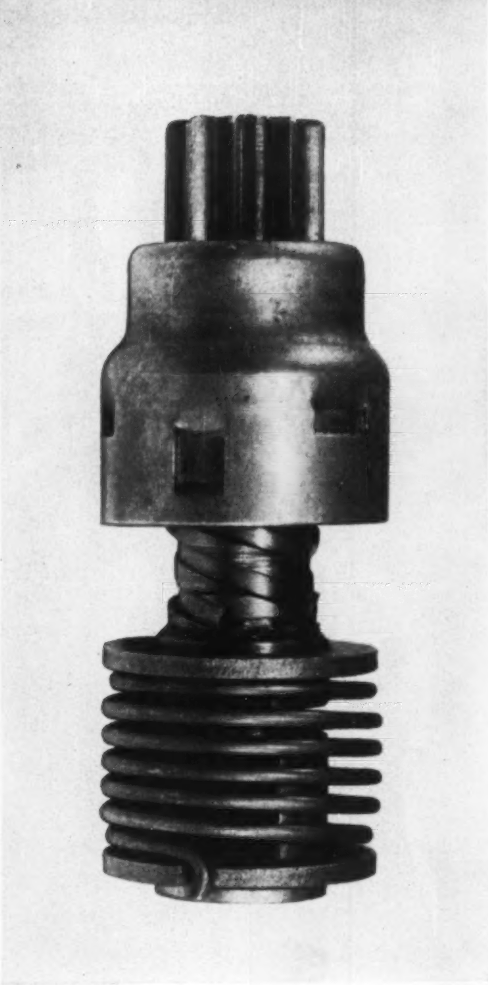
MS
HS6460



2.

3.

1. FIVE REPUBLIC METAL POWDERS give you broad spectrum coverage. Republic's wide range of iron and alloy powders cover all known physical property requirements of metal part fabricators. Send for booklet, ADV. 1014 for complete technical information on Types G, N, S, and Type MS. Information on Type HS6460 is contained in booklet, ADV. 1028. Write today.

2. REPUBLIC COLD DRAWN ALLOY STEEL is used by a leading manufacturer for one of the most critical components in their automobile starter drive assemblies—the drive pinion. Use of Republic Cold Drawn Alloy provides the necessary strength and toughness to withstand severe torque, impact, and prolonged wear. Write for additional information.

3. REPUBLIC NYLOK® FASTENERS provide secure holding power where it's needed most in the Twin Power Riding Mowers produced by Roberton Manufacturing Company, Chicago. A special nylon insert assures positive locking, maximum holding power—even under severe vibration. The insert in NYLON fasteners is unaffected by age or cold, has high resistance to heat. Send coupon for additional data.

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  ☐ Carbon ☐ Stainless
☐ Republic NYLOK Fasteners
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☐ ADV. Booklet 1014
☐ ADV. Booklet 1028

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Company________________________________
Address________________________________
City____________________Zone____State________

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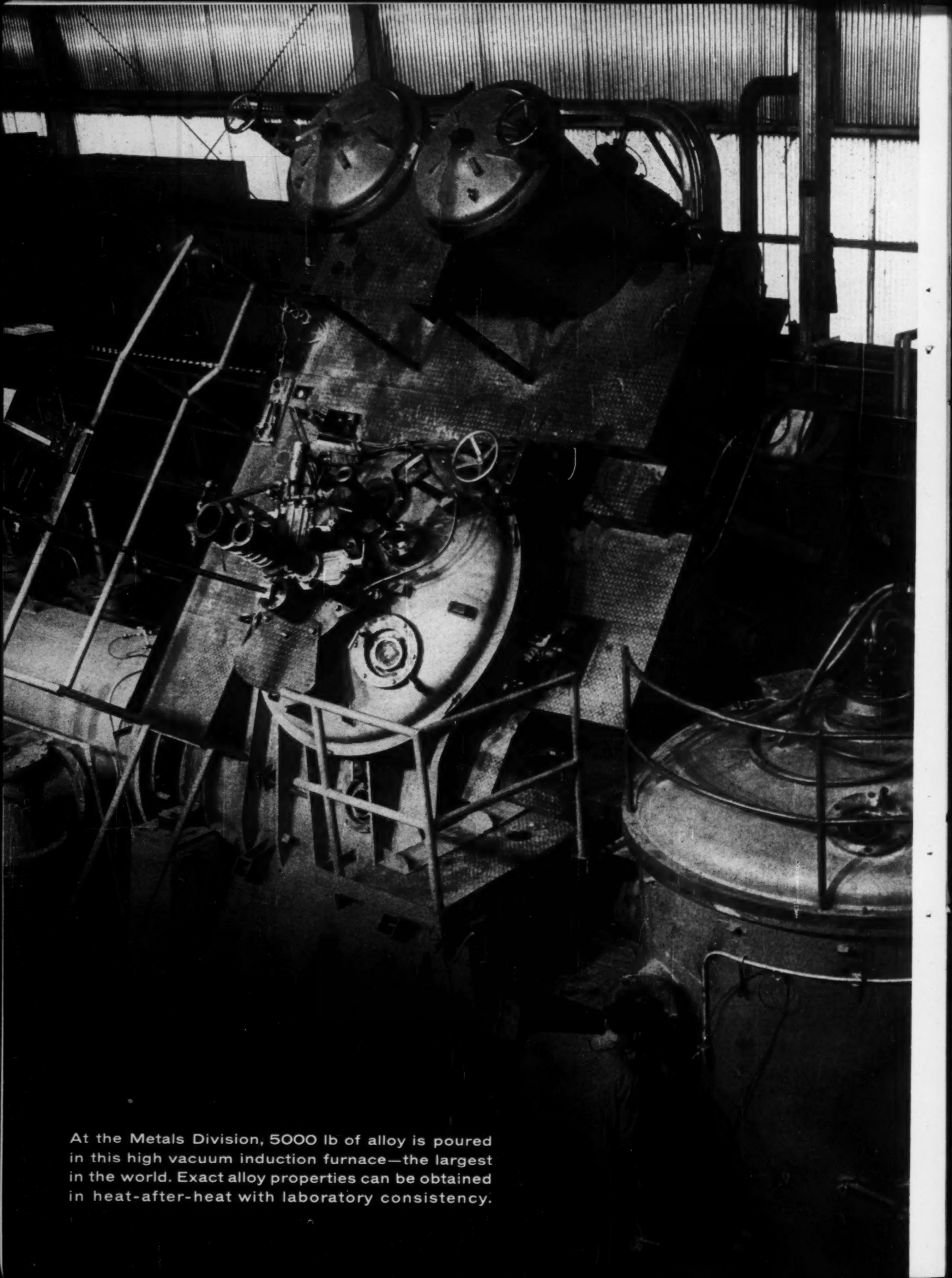


At the Metals Division, 5000 lb of alloy is poured in this high vacuum induction furnace—the largest in the world. Exact alloy properties can be obtained in heat-after-heat with laboratory consistency.

Are you after highest alloy properties in heat-after-heat?

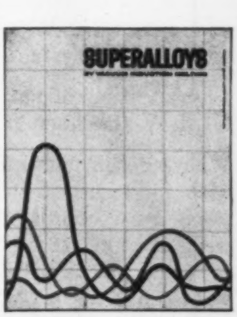
100 per cent alloy composition control assured by vacuum induction melting

Highly reactive elements enhance high-temperature alloy properties. Today, only one production metal refining process can effectively control the action of these elements, and—heat-after-heat—meet the most exacting alloy specifications.

The process is vacuum induction melting, and the *only* specialist in this process is the Metals Division, Kelsey-Hayes Company.

In a specially designed plant which contains seven vacuum induction furnaces with a monthly capacity of 1 million lb, the Metals Division produces over 50 alloys for critical high-temperature, high-stress applications such as aircraft gas turbine buckets and wheels, missile and nuclear components. Alloys like Udimet 500 and 700 were developed by Metals Division. The Division is the leading producer of vacuum induction melted Waspaloy, M-252, and other alloys.

Write for Your Free Copy of the Metals Division's new 36-page book—"Superalloys by Vacuum Induction Melting." Dept. 10A, Metals Division, Kelsey-Hayes Company, New Hartford, New York.



METALS DIVISION
KELSEY-HAYES COMPANY
NEW HARTFORD, NEW YORK

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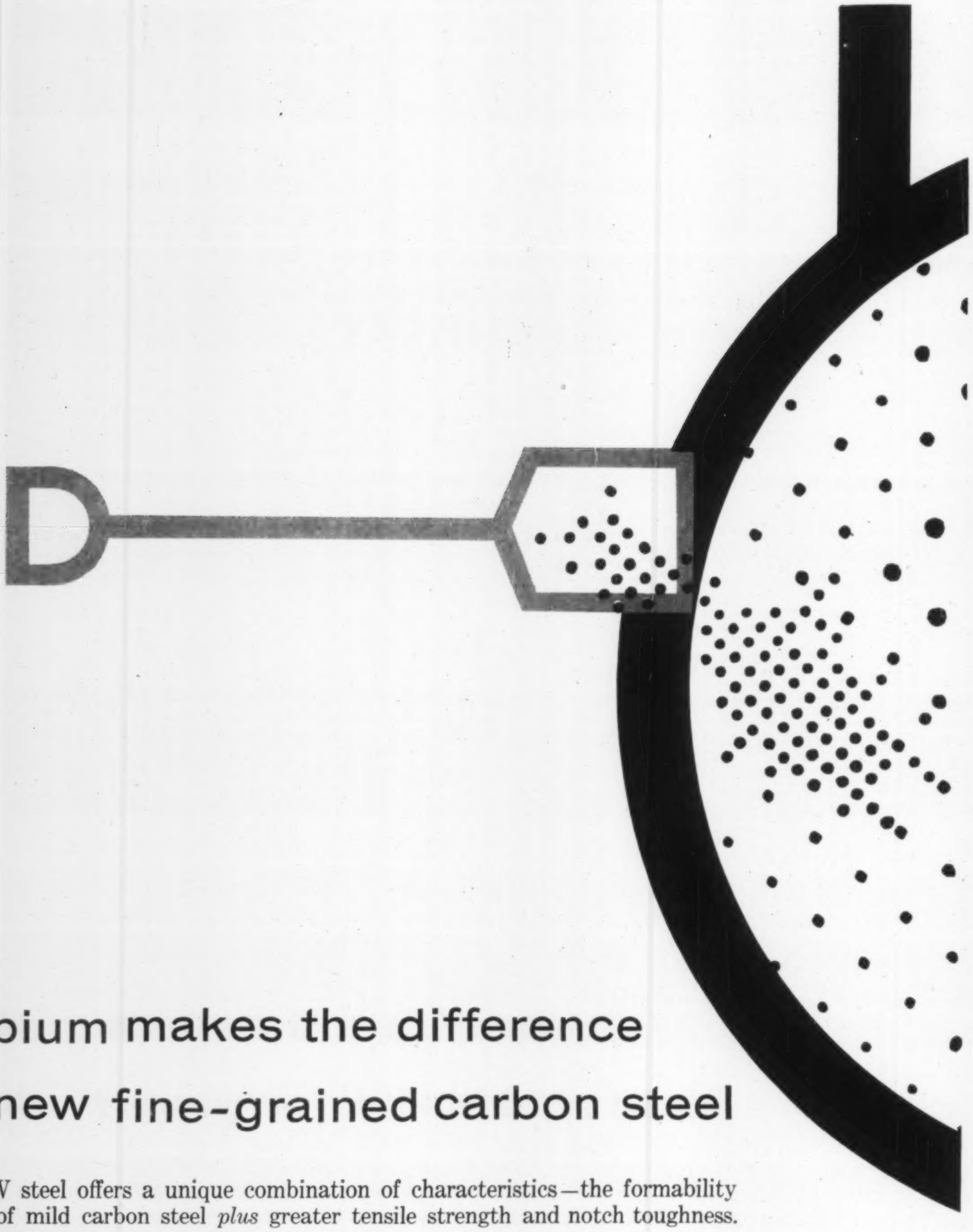

Columbium makes the difference in this new fine-grained carbon steel

The new GLX-W steel offers a unique combination of characteristics—the formability and weldability of mild carbon steel *plus* greater tensile strength and notch toughness.

The addition of small amounts of columbium gives GLX-W the finer grain structure that makes this possible.

Where design permits, the use of GLX-W can result in weight savings up to 35%, compared with mild carbon steel. With yield strengths ranging from 45,000 to 60,000 psi, GLX-W steels are recommended for a broad range of applications. For technical information, write to our Product Development Division, Department A.

GREAT LAKES STEEL
Detroit 29, Michigan

Great Lakes Steel is a Division of **NATIONAL STEEL CORPORATION**

GLX-W

GLX W

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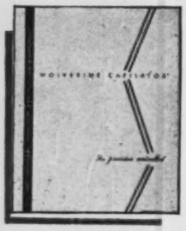
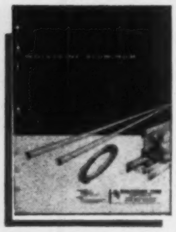
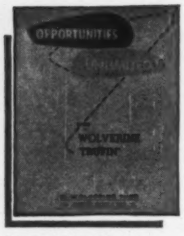


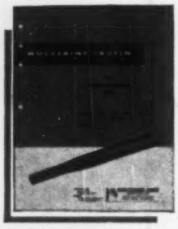
1. Wolverine Capilator Catalog



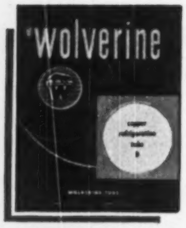
2. Wolverine Aluminum Catalog



3. Opportunities Unlimited

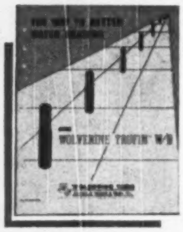


4. Wolverine Trufin Catalog



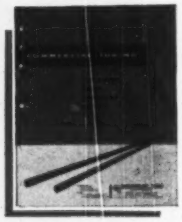
5. Copper Refrigeration Tube Book

6. Measure of Tubemanship



10. Water Heater Catalog

7. Design & Cost Comparison

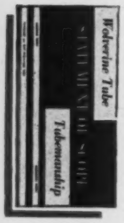


11. Commercial Tubing Book

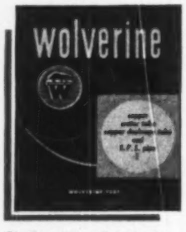
Process Flowsheets

8. Process Flowsheets

12. Wolverine Serves
The Refrigeration Industry



9. Statement of Scope



13. Copper Water Tube Catalog

When it comes to tube...
come to Wolverine

From Wolverine Tube, manufacturers can obtain a great variety of tubular products. These range from such products as tiny, plug-drawn Wolverine Capilator® used for restriction purposes, to commercial copper tube up to 6 inch O.D. and aluminum tube to 3 inch O.D.

Illustrated on this page—and reading like tubing's "best seller" list—is the latest Wolverine Tube literature dealing with all the company's products and specialized services. Look these catalogs over. A request, on your letterhead, will bring you the catalog . . . or catalogs . . . of your choice without delay or obligation. Just write Dept. S—TODAY!

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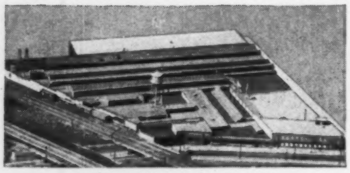
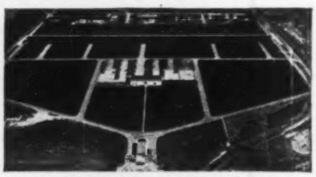


DETROIT, MICHIGAN



DECATUR, ALABAMA

14. Wolverine Corrosion Chart

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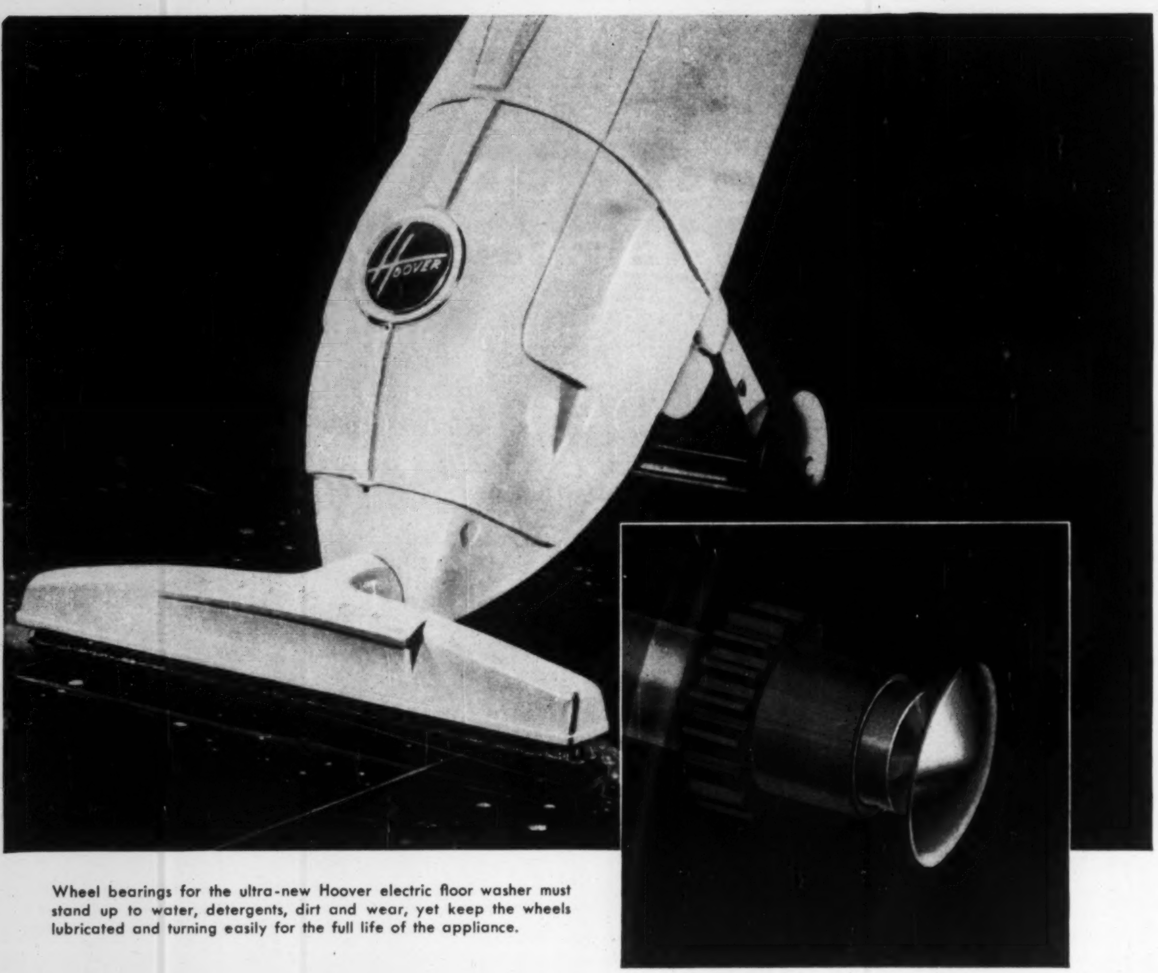

Wheel bearings for the ultra-new Hoover electric floor washer must stand up to water, detergents, dirt and wear, yet keep the wheels lubricated and turning easily for the full life of the appliance.

GLIDDEN POWDERED METALS KEEP THE WHEELS TURNING

Among the many unique problems faced by The Hoover Company in designing the world's first electric floor washer and dryer for home use, was the important matter of wheel bearings.

These bearings had to endure moisture, dust, grit and detergents, yet provide a close-tolerance, self-lubricating surface for upwards of ten years' hard use.

Hoover engineers, working closely with Glidden technicians and a powdered metal parts producer, came up with the answer —oil-impregnated sintered bronze bearings made with Glidden Resistox powdered metal.

Perhaps you, too, have a demanding problem for which sinterings can provide the solution.

As a leading supplier of metal powders, Glidden works closely with parts producers. This places several staffs of experienced engineers at your service, providing complete technical service.

We welcome your inquiries.

QUALITY Glidden PRODUCTS

RESISTOX METAL POWDERS
The Glidden Company
Chemicals—Pigments—Metals Division
Hammond, Indiana

COPPER POWDER • LEAD POWDER • TIN POWDER • BRASS POWDER • ALLOY POWDER • FILTER POWDER
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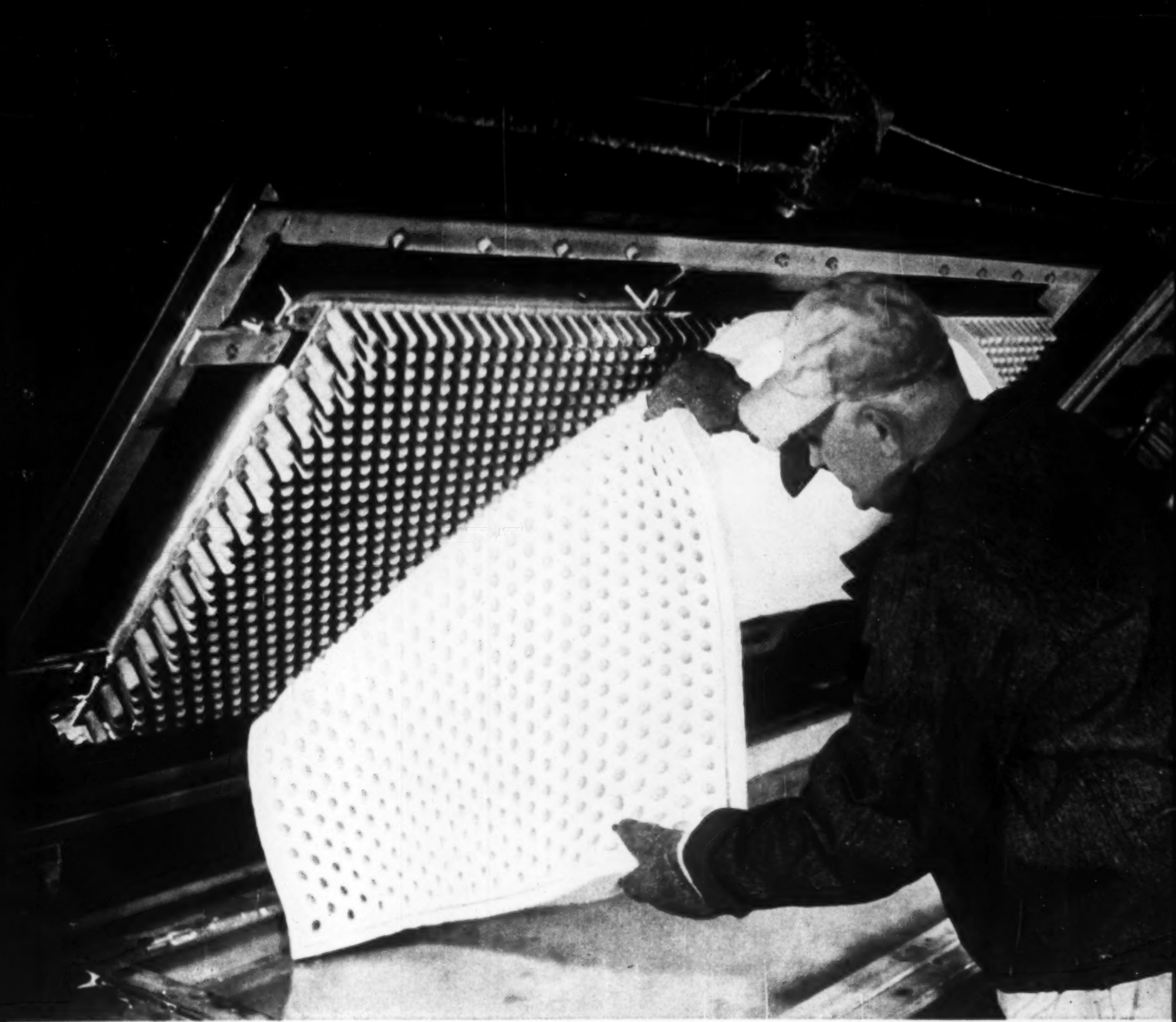
For more information, circle No. 442 ➤



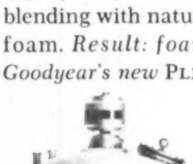
Announcing Pliolite Latex 5352—for the foam of the future

All-synthetic foam rubber is here—made from a new synthetic rubber latex by Goodyear. Its name: Pliolite Latex 5352. Already interested: the automotive industry, furniture companies, shoe manufacturers—even firms that have never used foam before!

Why all this interest? Pliolite Latex 5352 is of such high quality that it can be used alone, does not require blending with natural latex to produce an outstanding foam. *Result: foam rubber cushioning made from Goodyear's new* Pliolite Latex 5352 *will be substantially lower in cost than any foam ever used in commercial products before.*

Another key point: because this new Goodyear latex is man-made, its fine quality will not fluctuate.

If your products can profit from a low-cost foam with excellent compression characteristics, good resilience, remarkable stress resistance and great durability—it will pay you to investigate Pliolite Latex 5352. Write for details to: Goodyear, Chemical Division, Dept. M-9437, Akron 16, Ohio.



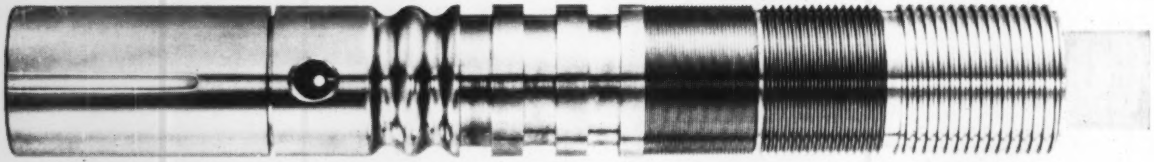
GOODYEAR

CHEMICAL DIVISION

Pliolite—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

THEY LAUGHED WHEN WE SAT DOWN TO PLATE...

they didn't know about KANIGEN®



This shaft was turned. It was key-slotted, drilled, tapped and shouldered. It was threaded, milled, grooved and chamfered. It was step-bored, with three inside diameters. Who could plate a piece like this all over—inside and out—and expect a uniform coating?

Well, anyone who used KANIGEN® could expect it—and get it. In fact, we made this piece especially to prove it.

The KANIGEN® process for chemical nickel alloy plating produces a uniform thickness of coating, regardless of the contours of a part. This uniformity permits full machining operations prior to coating, with no subsequent cleanup.

KANIGEN® offers corrosion resistance equal or superior to that provided by wrought or electrolytic nickel.

For complete technical details write or call your nearest General American office. Ask for Kanigen Bulletin No. 258. You'll find that with plating as in so many other industrial areas, *it pays to plan with General American.*

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an exciting new plastic laminate!

REQUIRES NO SPECIAL TOOLS

Here's a beautiful, hard surface plastic laminate that can be applied to chipboard, hardboard, plywood, steel or any other sound surface with ordinary tools. It's self-edging . . . wipes clean with a swish of the cloth. The wood finishes LOOK LIKE WOOD . . . no glisten and gleam . . . just a soft, rich, fine lustre. You can almost feel the grain! Best of all, Kevinite is available in easy-to-stock, easy-to-handle rolls. Or, if you prefer, in sheets of any length. So easy to use that even a do-it-yourselfer completes professional looking jobs. Get the facts on Kevinite today.

DECORATOR-STYLED FINISHES . . .

in the most wanted patterns!

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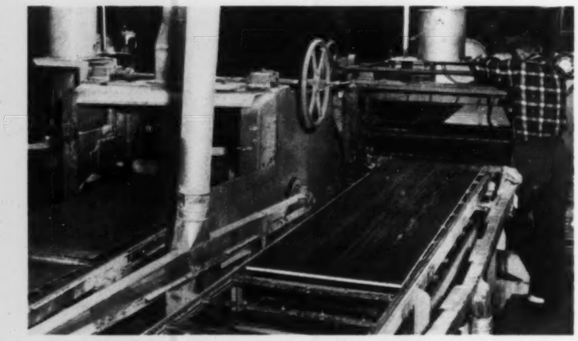
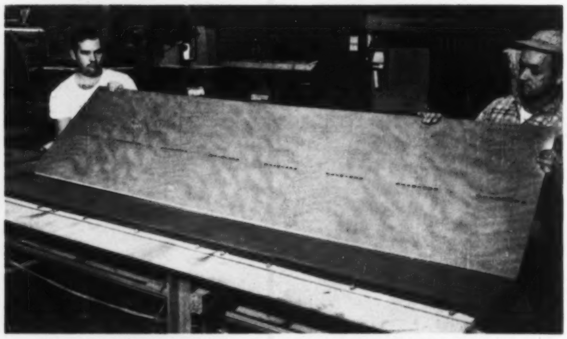
Swedlow INC.

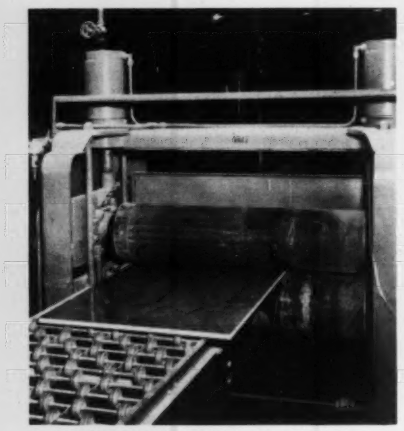
LOS ANGELES 22, CALIFORNIA
YOUNGSTOWN 9, OHIO



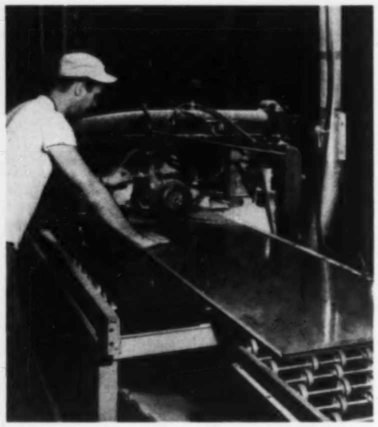
ADHESIVE LINE at left coats bottom of Kevinite. Line at right coats top and bottom of flakeboard core.



HAND POSITIONED KEVINITE positioned on one long sheet of flakeboard. Kevinite is delivered cut-to-size.



POWER ROLLERS completely bond Kevinite to flakeboard. Bond is permanent . . . surface is completely smooth.



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LIFETIME SURFACE looks like fine wood. Door edge has been routed and covered with plastic T-section.

Perfect Laminate for OEM *Applications*

Kevinite is a durable, stain-resistant, flexible, thermosetting, plastic laminate available in rolls or sheets. Standard patterns appear on other side of this page. Proprietary patterns can be developed for your exclusive use. Kevinite bonds to any sound surface and can be handled like a veneer. No special tools or equipment required. It can be die-cut. The entire operation pictured here is handled with standard woodworking equipment.

We will work with you on your application problems.

PHYSICAL PROPERTIES

• Thickness (in.)	.031
• Weight (lbs./sq. ft.)	.224
• Tensile (warp) PSI (lbs./sq. in.)	8,500
• Barcol Hardness	45
• Water Absorption % (24 hr. immersion)	3.8
• Heat Resistance Hot Iron at 375°	Possible slight discoloration after 10 min.
• Water Spot Test (24 hr. exposure)	No effect
• Surface not affected by normal household products	
• Over-lay Thickness	.0025

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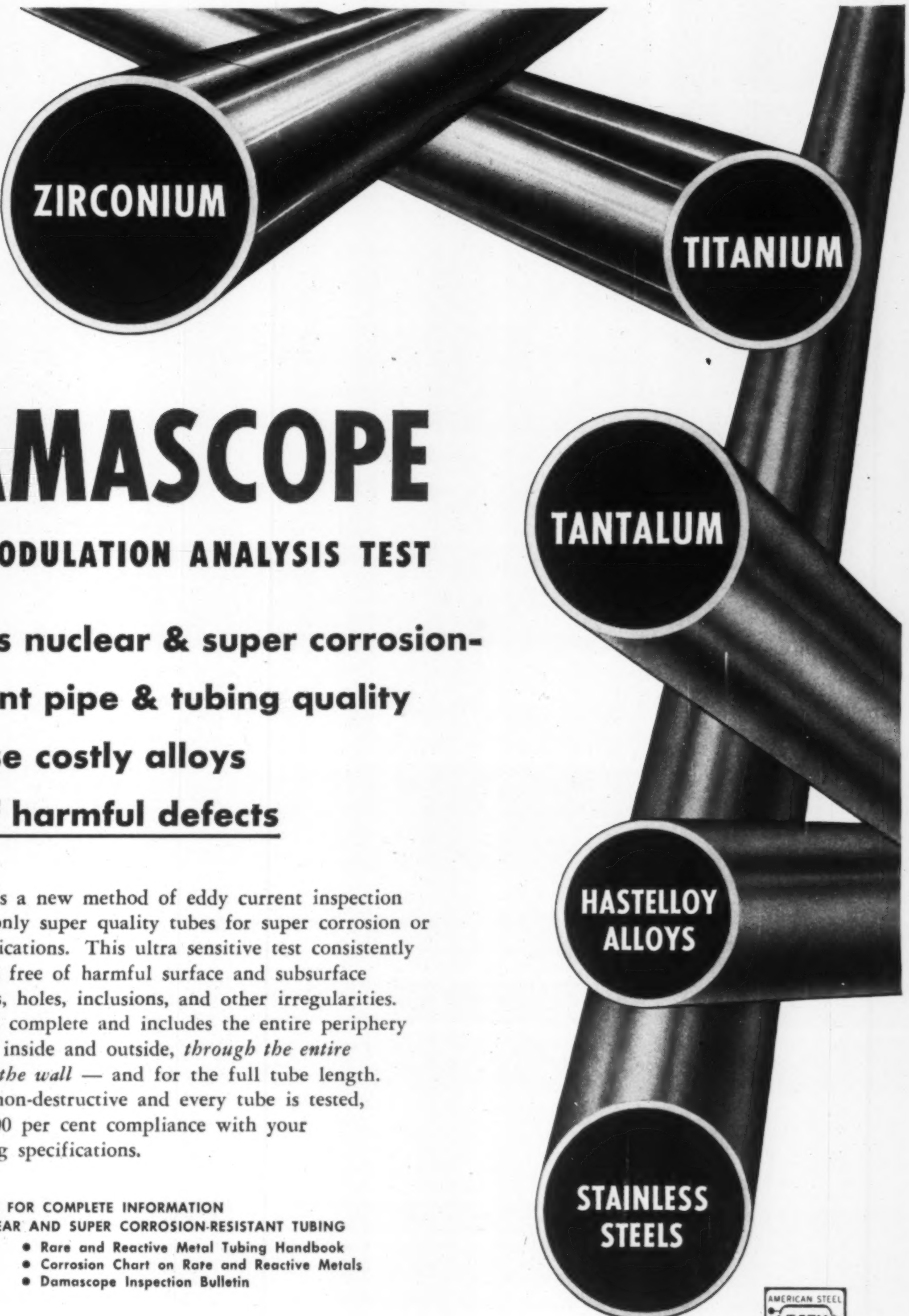
Swedlow, INC. LOS ANGELES 22, CALIFORNIA/YOUNGSTOWN, OHIO



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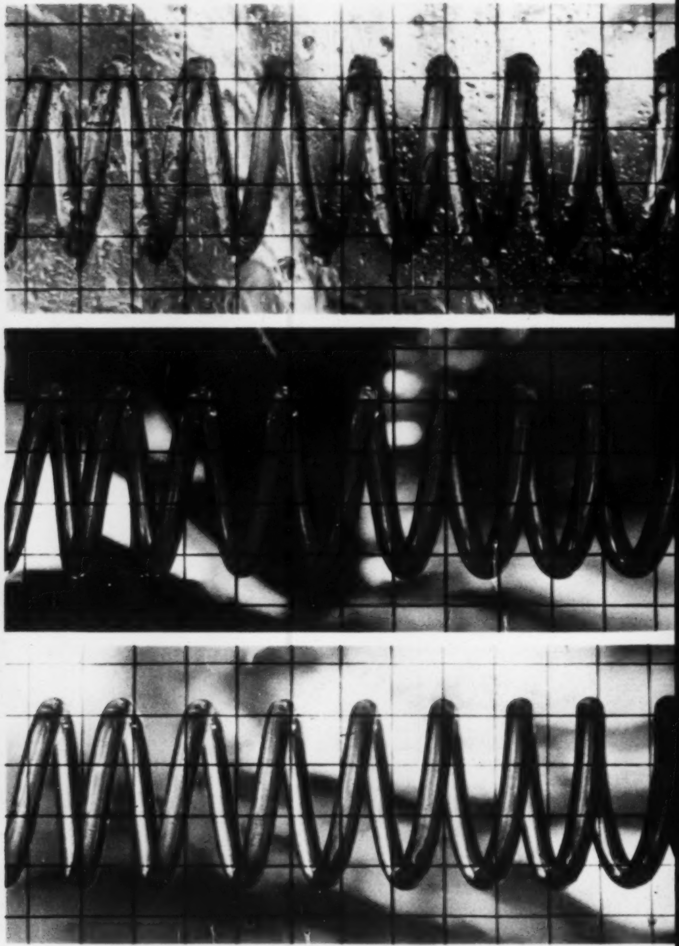
POLYCARBONATE

EXCEPTIONAL MECHANICAL STRENGTH

(Example: 12 to 16 ft-lb/in. notched Izod impact strength—see table)

SUPERIOR DIMENSIONAL STABILITY

(Example: Low Water Absorption—see table)



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New MERLON combines in one material the most sought-after engineering properties near the ultimate specification level. It is not only a new thermoplastic resin, but represents a new approach to the whole material specification assignment in industry.

In addition to the major properties illustrated, MERLON polycarbonate is transparent, has low water absorption, is non-staining, self-extinguishing, odorless and tasteless. It can be fabricated by injection molding, extrusion, and vacuum forming on stand-

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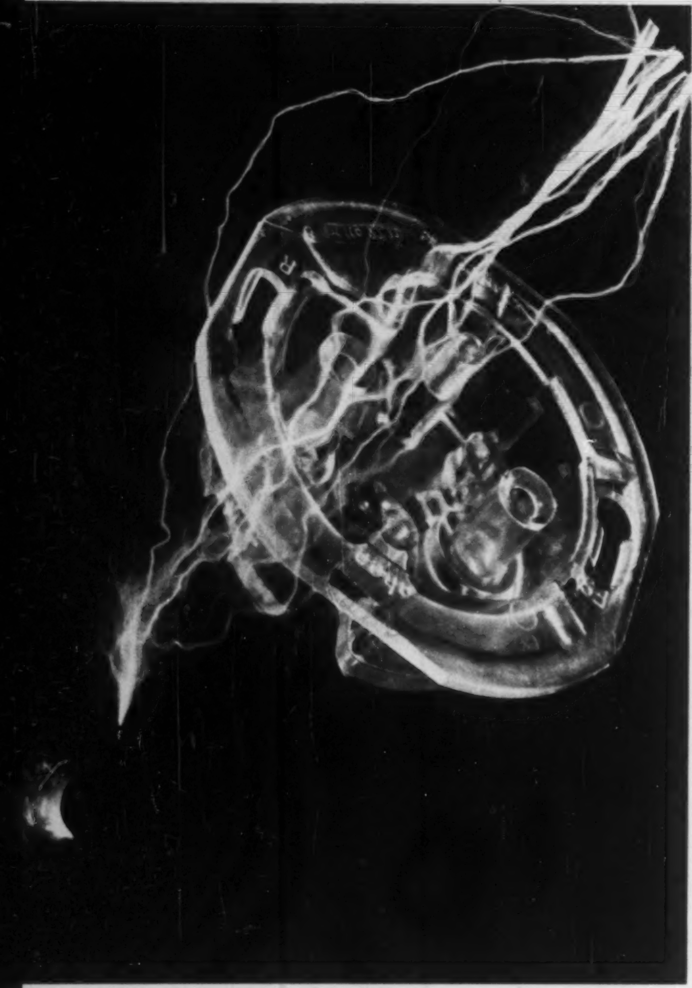
POLYCARBONATE

GOOD ELECTRICAL PROPERTIES

(Example: 440 volts/mil dielectric strength, short time—see table)



PROPERTIES OF MERLON® POLYCARBONATE RESIN

PROPERTY	ASTM NO.	VALUE*
MECHANICAL		
Impact strength, Izod (notched)	D-256 (½″ x ½″) (½″ x ⅛″)	2 to 3 ft-lb/in. 12 to 16 ft-lb/in.
Tensile strength and yield point	D-638	8,000-9,000 psi
Elongation, at yield	D-638	5-6%
Elongation, ultimate	D-638	60-100%
Compressive stress at yield point	D-695	12,000 psi
Deformation under load	D-621	0.14%
Flexural strength	D-790	11,000-13,000 psi
Modulus of elasticity		
Tension	D-638	$2.8\text{-}3.2 \times 10^5$ psi
Flexural	D-740	$3.2\text{-}3.4 \times 10^5$ psi
Rockwell hardness	D-785	R 115
ELECTRICAL		
Dielectric constant	D-150	
60 cycles		2.95
10^6 cycles		2.90
Dielectric strength, short time	D-149	440 V/mil
Dissipation factor		
60 cycles	D-150	0.0007
10^6 cycles		0.0100
Volume resistivity		
Dry		1.2×10^{16} ohm/cm
4 days at 80% rel. humidity		9×10^{14} ohm/cm
Arc resistance	D-495	12 sec

PROPERTY	ASTM NO.	VALUE*
THERMAL		
Heat distortion	D-648	
264 psi		280°F
66 psi		290°F
Specific heat		0.28 cal/°C/gm
Coeff. of expansion	D-696	7×10^{-5} in./in./°C
Melting temperature		425-440°F
Crystalline melting temp.		505°F
Flammability (in./min)	D-635	Self-extinguishing
MISCELLANEOUS		
Specific gravity	D-792	1.20
Refractive index	D-542	1.587 N_D25°C
Clarity		Transparent
Water absorption 24 hr immersion	D-570	0.3%
Effect of sunlight		None to slight
Outdoor aging		Good

*These values have been obtained under standard ASTM and laboratory test conditions. As averages, these values do not necessarily represent minimum material specifications.

ard equipment. Finished parts have brilliant surface gloss, can be machined, sawed, cut or stamped; easily bonded with appropriate solvents; readily heat welded or sealed. Plasticizers are not necessary; dyes and pigments can be added for a full range of transparent or opaque colors.

Examine MERLON's qualifications shown in the chart under the flap of this advertisement—check it against "problem" materials you may now be using. It's very possible that MERLON is the optimum material you've been searching for. MERLON's full range of engineering properties opens the door to a wide variety of redesign possibilities that could mean lower cost and improved performance of your products and components.

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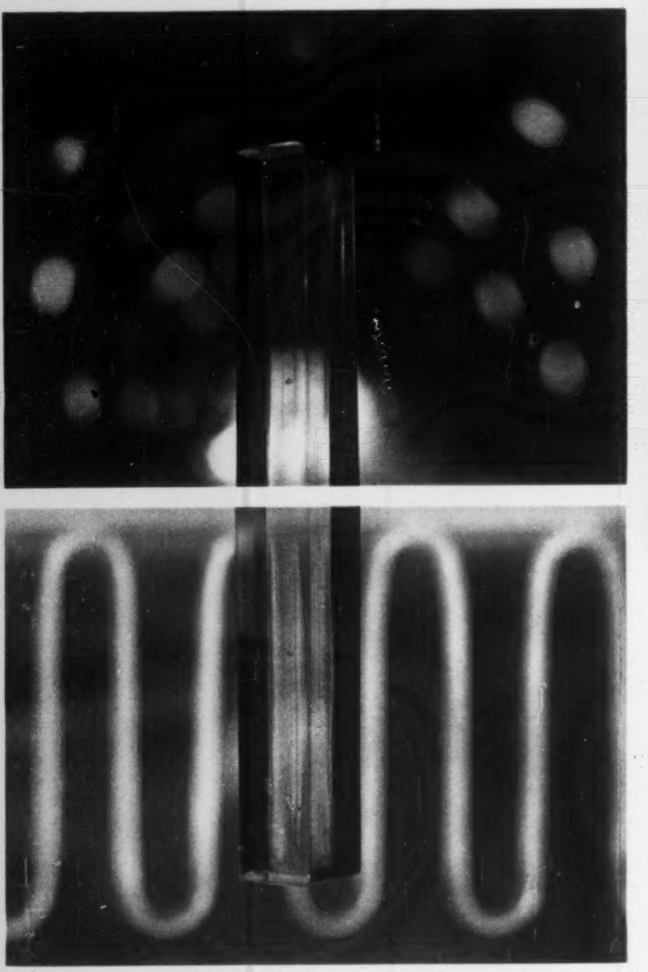

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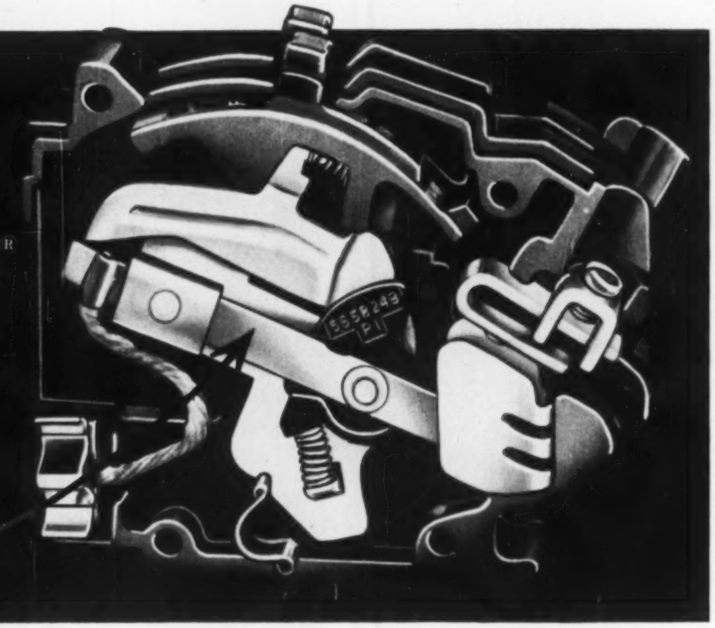


of TRUFLEX® Thermostat Metal Parts

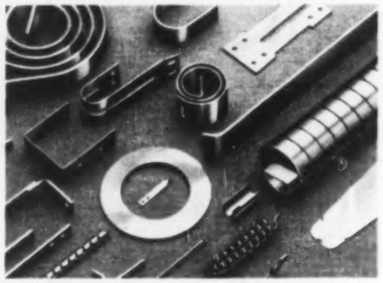
Meets General Electric's High Material Performance Requirements for New CIRCUIT BREAKERS

General Electric Type TR
"Twin" Circuit Breaker

The new General Electric "Twin"* Circuit Breaker for household applications combines two rugged breakers into a single one-inch case to allow up to twice as many circuits per load center. Because quality and dependability are a must, General Electric Circuit Protective Devices Department used TRUFLEX Thermostat Metal parts in their Type TR "Twin"* Circuit Breakers.

TRUFLEX is available in cut strips or long-length coils to meet your needs, or can be furnished in formed elements or completed assemblies fabricated to the most exacting parts' specifications. Either way you get accurate, consistent performance with TRUFLEX because every repeat order is an exact duplicate of the original — dependably uniform in activity, temperature range, electrical and corrosion resistance.

To new or regular users of thermostat metal, Metals & Controls has much to offer — over 60 types of TRUFLEX Thermostat Metal (resistivity from 15 to 850 ohms per c.m.f.) — complete technical literature on TRUFLEX — help with parts design — calibrated samples. Our competent field engineers will gladly call at your request. No obligation. Write today.



A few typical TRUFLEX formed elements fabricated for many Metals & Controls' customers.

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Suppliers' New Bulletins

Pressure Vessel Alloys. Airite Products Inc., 12 pp, illus., No. 141. New techniques for making titanium, stainless steel and alloy steel pressure vessels for missiles. (1)

Cr-Mo-V Steel. Allegheny Ludlum Steel Corp., 24 pp, illus. Design data, properties, uses and heat treatment for a chromium-molybdenum-vanadium high strength steel. (2)

Aluminum Pipe Fittings. Aluminum Co. of America, 8 pp, illus. Characteristics and sizes of aluminum pipe fittings. (3)

High Purity Aluminum. Aluminum Foils Inc., 8 pp, illus. Properties, uses, workability, handling characteristics, reflectivity and corrosion resistance of high purity aluminum ingots, billets, pellets, coiled sheets and foil. (4)

Copper Alloy for Dies. Ampco Metal Inc., 4 pp, No. G55. Advantages and typical applications of a new copper-base alloy used for forming, drawing and bending dies. (5)

Stainless Tubing, Pipe. Babcock & Wilcox Co., Tubular Products Div., No. TDC-195. Properties, chemical composition, size ranges, and short-time high temperature tensile and rupture properties of stainless steel tubing, pipe, and welding fittings. (6)

Acrylic-Type Polymer. J. T. Baker Chemical Co. Properties and uses of an acrylic-type polymer suitable for injection molding and extrusion. (7)

Liquid Polyvinyls. Bee Chemical Co., 16 pp, illus. Properties, advantages and methods of applying liquid polyvinyls on fabrics, steel, wire and clay products. (8)

Nylon Resins. Belding Corticelli Industries, 4 pp, No. X1. Properties and fabricating data for the 1100 series of nylon resins. (9)

Filter Element Materials. Bendix Aviation Corp., Bendix Filter Div., 2 pp, illus. Describes seven basic filter element materials and various types of filter assemblies and replacement elements. (10)

Strippable Plastic Coatings. Bischoff Chemical Corp., 4 pp, illus. Shows how tools and small metal parts can be protected by a tough, transparent strippable coating. (11)

Phosphor Bronze Rod. Bridgeport Brass Co. Physical, mechanical and fabricating properties of phosphor bronze rod. (12)

Protective Coatings. Columbia Technical Corp., 6 pp, No. 590915. General classification, and thermal, physical, electrical and chemical properties of protective coatings for electronic applications. (13)

Plastics Moldings. Continental-Diamond Fibre Corp., 12 pp, illus. Information on compression, transfer and injection molded plastics parts. Properties of molding materials and typical molded parts. (14)

Copper and Its Alloys. Copper & Brass Research Assn., 34 pp, illus., No. 15. Mining methods, properties, fabrication data, uses, and production and consumption of copper and its alloys. (15)

Moisture Resistant Coating. Corrosion Reaction Consultants Inc., 6 pp. Information on a moisture and corrosion resistant treatment for electrical and electronic equipment. (16)

Die Castings. Dow Chemical Co., Dow Metal Products Co. Div., 12 pp, illus. Information on magnesium die castings used in automobiles, appliances, electric motors, business machines and hand tools. (17)

Elastomer-Coated Fabrics. E. I. du Pont de Nemours & Co., Inc., Fabrics Div., 12 pp, illus. Uses, properties, sizes and specifications of synthetic elastomer-coated fabrics. (18)

Nylon and Dacron Ropes. E. I. du Pont de Nemours & Co., Inc., Textile Fibers Dept., 12 pp, No. X-92. Discusses the effect of loading on the extension and recovery of nylon and Dacron rope. (19)

Epoxy Adhesive. Fenwal, Inc., 2 pp, illus. Tells how to mix and apply a ready-to-use epoxy adhesive. (20)

Lithium Metal. Foote Mineral Co., 8 pp, No. 101. Available forms, uses, and physical, mechanical, thermal, optical, nuclear and chemical properties of lithium metal. (21)

Properties of Stainless Steels. Peter A. Frasse & Co., Inc., Sec. A, No. 4. Data chart provides a comparison of properties for 18 different grades of stainless steel. (22)

Epoxy Adhesives, Coatings. H. B. Fuller Co., 48 pp. Properties, characteristics, directions for use, and typical applications of epoxy adhesives, sealants and protective coatings. (23)

Plastics Tooling. Furane Plastics Inc., 4 pp, illus., No. EP-58-7. Available materials, manufacturing procedures and typical applications of plastics tooling materials. (24)

Silicone Rubber. General Electric Co., Silicone Products Dept., 4 pp, illus., No. CDS-179. Properties, advantages and uses of silicone rubber insulation. Compares silicone rubber with PVC, neoprene and natural rubber. (25)

Injection Molded Acetal. Gries Reproducer Corp., 8 pp, illus., No. 1001. Mechanical, chemical and physical properties of acetal plastics, including a table of approximate dimensions and weights in which molded parts can be specified. (26)

Metal Castings. Hampden Brass & Aluminum Co., 6 pp, illus. Shows aluminum, zinc, brass, copper and nickel parts made by die casting, permanent mold casting and sand casting. (27)

Alnico Permanent Magnets. Indiana Steel Products Co., 2 pp, No. 350. Magnetic, mechanical, and general characteristics and applications of Alnico permanent magnets. (28)

Metallic, Nonmetallic Balls. Industrial Tectonics, Inc., 8 pp, illus., No. Bu-1. Manufacturing methods, finishes, sizes and quantities of ferrous, nonferrous, nonmetallic, plastics and special balls used for valves, pumps, bearings, ball point pens, etc. (29)

Corrosion Resistant Nickel Alloy. International Nickel Co., Inc., Huntington Alloy Products Div. Information on corrosion resistance, physical constants, tensile properties and fabrication of a new corrosion resistant nickel alloy. (30)

Aluminum Casting Alloy. William F. Jobbins, Inc., 8 pp, illus., No. 354.

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Composition, advantages, physical properties, machinability, corrosion resistance, welding data and applications of an aluminum casting alloy. (31)

Aluminum Bronze Bars. Johnson Bronze Co., 4 pp, illus. Advantages of both solid and centrifugally cast, cored aluminum bronze bars. (32)

Low Alloy, High Strength Steel. Jones & Laughlin Steel Corp., 24 pp, illus. Applications, and physical, chemical and mechanical properties of a low alloy high strength steel. (33)

Cobalt-Chromium Superalloy. Kelsey-Hayes Co., Metals Div., 8 pp, illus. Chemical composition, physical constants, mechanical properties, isostress curves, heat treatment, finishing and available forms of a cobalt-chromium superalloy used in jet engines, missiles and electronic tubes. (34)

Abrasive Finishing of Aluminum and Magnesium. Lea Mfg. Co., 1 p. Data on wheel heading, lubrication, speed, and type of buff used to produce satin, matte, butler and bright finishes on aluminum and magnesium castings, formed parts, extrusions, spinnings and stampings. (35)

Epoxy Tooling Materials. Marblette Corp., 2 pp. Describes abrasion resistance, pot life, color, viscosity, shrinkage and chemical resistance of epoxy tooling materials. (36)

Meehanite Standard Shapes. Meehanite Metal Corp., 714 North Ave., New Rochelle, N. Y., 16 pp, illus., No. 45. Describes the use of standard Meehanite bars, bushings and shapes for cams, pistons, gears, plates, etc. Write on company letterhead directly to Meehanite Metal Corp.

Anti-Static Coating for Plastics. Merix Chemical Co., 4 pp, illus., No. 5. Applications and characteristics of an improved anti-static material for plastics. (38)

Fluorinated Elastomer. Minnesota Mining & Mfg. Co., Chemical Div., 4 pp. Thermal stability, chemical resistance, mechanical and electrical properties, weathering and ozone resistance, and applications of a fluorinated elastomer. (39)

Electrical Insulating Varnishes. Minnesota Mining & Mfg. Co., Irvington Div., 35 pp, illus. Electrical, mechanical and physical properties of electrical insulating varnishes. (40)

Wire Cloth. Newark Wire Cloth Co., 4 pp, illus. How to select, use and check various grades and types of wire cloth. (41)

Laminated Plastics. Northern Plastics Corp., 8 pp, illus., No. 2b/No. Properties, availability and fabrication of laminated plastics sheets, fabricated parts and printed circuits. (42)

Plastics Molding. Richardson Co., 4 pp, illus., No. 01.000.3. Advantages of compression and transfer molded parts used in the appliance, automotive, aircraft and electrical industries. (43)

Welded Hydraulic Fluid Line Tubing. Joseph T. Ryerson & Son, Inc. Complete engineering data on cold drawn, welded hydraulic fluid line tubing. (44)

Gold Plating Formulation. Sel-Rex Corp., 7 pp, No. 46A. Metallurgical properties and applications of a low pH acid-type gold plating formulation. (45)

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Aluminum Sheet, Coil, Strip. Sheet Aluminum Corp., 4 pp, illus. Custom rolling of aluminum sheet, coil and strip. (47)

Ingot Iron Tubing. Superior Tube Co., 2 pp, No. 18. Nominal chemical analysis, mechanical and physical properties, standard production limits, standard tubing tolerances, fabrication and heat treatment of ingot iron tubing. (48)

High Strength Titanium Alloy. Titanium Metals Corp. of America, 24 pp, illus., No. 8. Heat treatment, fabrication characteristics, and physical, mechanical and design properties of a high strength titanium alloy. (49)

Tool Steel. Uddeholm Co. of America, Inc., 8 pp, illus. Information on forging, stress relieving, carburizing, quenching, tempering and martempering a low carbon tool steel used for molds for plastics and die casting dies for zinc and other low melting metals. (50)

Phenolic Molding Compound. Union Carbide Plastics Co., Div. of Union Carbide Corp., 12 pp, No. 36. Lists resistance of seven phenolic molding compounds to acids, alkalis, solvents and common mixtures. (51)

Finish for Wood Furniture. Watco-Dennis Corp., 4 pp, illus., No. 25-B-22(NN). General description, appearance, use and application data for a natural wood furniture finish. (52)

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Iron Powder. Alan Wood Steel Co., 5 pp, illus. Molding and sintering properties of iron powder made by the H-Iron process. 53

Ferrous Alloy Castings. American Manganese Steel Div., American Brake Shoe Co., 8 pp, illus., No. S-57. Properties of alloy steel and iron castings. 54

Aluminum-Coated Steel Wires. Page Steel & Wire Div., American Chain & Cable Co., Inc., 6 pp, illus., No. DH-53 7B. Properties and uses of hot-dip and aluminum-coated steel wires and wire products. 55

Welded Steel Products. American Machine & Foundry Co., Cleveland Welding Div., 8 pp, illus. Information on circular, rolled-and-welded steel products. Discusses the Cleve-Weld process of Welding. 56

Vinyl-Metal Laminate. American Nickeloid Co., 6 pp, illus. Specifications, uses and fabrication of a vinyl-metal laminate available in sheets, strips and coils. 57

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Wire Parts, Small Stampings. Art Wire & Stamping Co., 4 pp, illus. Shows a variety of wire parts and small metal stampings in both ferrous and nonferrous metals. 59

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Corrosion of Wrought Iron. A. M. Byers Co., 8 pp, illus., No. 15-D. Compares corrosion resistance of 4-D wrought iron with standard wrought iron and a ferrous substitute in such applications as hot water lines, heat exchangers, smoke stacks, tanks and brine lines. 61

Specialty Steels. Carpenter Steel Co., 40 pp, illus. Properties and uses of tool and die steels, stainless steels, high temperature alloys, electronic, magnetic and electrical alloys, special purpose alloy steels, tubing and pipe, and fine wire specialties. 62

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Steel Wire. Continental Steel Corp., Kokomo, Ind. Information on coarse round, standard and special shaped wire made of low and medium low carbon steels. Write on company letterhead directly to Continental Steel.

Leaded Steels. Copperweld Steel Co., Aristoloy Steel Div., 16 pp, illus. Mechanical properties and workability of leaded steels. 66

Carbon, Alloy Steel Tubing. Ohio Seamless Tube Div., Copperweld Steel Co., 14 pp, illus., No. CP-3. Describes carbon and alloy seamless steel tubing in mechanical, pressure and aircraft mechanical grades. 67

Boron Stainless Steel. Superior Steel Div., Copperweld Steel Co., 8 pp, illus. No. 57. Chemical composition microstructure, corrosion resistance, machinability and mechanical properties of a boron stainless steel for nuclear reactors. 68

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Steel, Iron Castings. Goslin-Birmingham Mfg. Co., Inc., Contract Mfg. Div., 2 pp, illus., No. 708-1. Information on steel and iron castings, heavy machine work, plate fabrication, stress relieving, custom machinery and equipment, and large cast iron pipe and fittings. 73

Gray Iron Castings. Gray Iron Founders' Society, Inc., National City-E 6th Bldg., Cleveland 14, Ohio, 75 pp. Contains an alphabetical list of members of the Society, a geographical listing of members, and a buyers' guide section. Write on company letterhead directly to Gray Iron Founders' Society.

Ductile Iron. Hamilton Foundry Inc., 6 pp, illus. Tensile strength, machinability, heat resistance, pressure tightness, impact resisance and rigidity of ductile (nodular) iron. 74

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Malleable Iron Castings. National Malleable & Steel Castings Co., 8 pp, illus. Describes the manufacture of HTM pearlitic malleable iron castings. Includes chemical composition, physical properties and machinability. 83

Copper-Coated Wire. National-Standard Co., 8 pp, illus., No. 202. Uses, corrosion resistance, strength, electrical resistivity and bend strength of copper-coated wire. 84

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Nonferrous Shapes. American Brass Co., 20 pp, illus., No. B-28 S. Composition, forms and physical properties of copper, bronze, nickel silver, phosphor bronze, leaded brass and special brass alloys. 107

Fabricated Metal Products. American Brass Co., Fabricated Metal Goods Div., 8 pp, illus., No. BG-5. Information on fabricated metal products made of copper, brass, bronze, nickel silver, iron, steel, stainless steel and aluminum. 108

Bronze Casting Alloys. American Manganese Bronze Co., 50 pp, illus. Composition, characteristics and applications of the principal copper alloys used to make castings. 109

Electrolytic Copper Powder. American Metal Climax, Inc., 8 pp, No. CP-101. Describes the operation, equipment and quality control used in the production of electrolytic copper powder. 110

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Extruded Aluminum Shapes. William L. Bonnell Co., Inc., 6 pp, illus. Information on specially treated extruded aluminum shapes for marine applications. Information also on vinyl extrusions. 116

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Magnesium Casting Alloy. Magnesium Elektron Inc., 12 pp, illus. Tensile, and short-time and long-time creep and fatigue properties of a high strength magnesium casting alloy. 131

Uses of Tin. Malayan Tin Bureau, 18 pp, illus., No. 45. Current issue of "Tin and Its Uses" discusses an organo-tin compound as textile preservatives, and slow-brightened electro-tin in electronic equipment. 132

Sintered Nonferrous Metal. P. R. Mallory & Co., Inc., 4 pp, illus. Gives physical, compression, torsion, tension and bending properties of a sintered tungsten-nickel-copper alloy for gyroscope applications. 133

Die Castings. Doehler-Jarvis, Div. of National Lead Co., 6 pp, illus. Advantages and limitations of zinc, aluminum and magnesium die casting alloys. Case histories on the use of die castings in chain saws and movie cameras. 134

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Magnetic Perforating Dies. S. B. Whistler & Sons, Inc., 21 pp, illus., No. M-45. Catalog of magnetic perforating dies for perforating materials up to and including ¼-in. thick mild steel. 150

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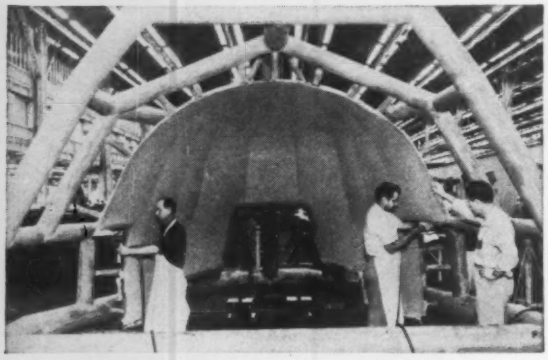

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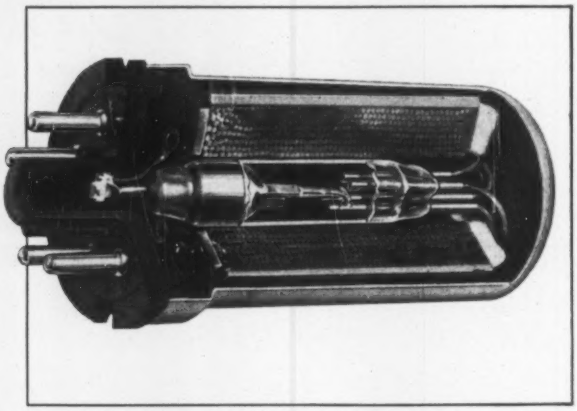

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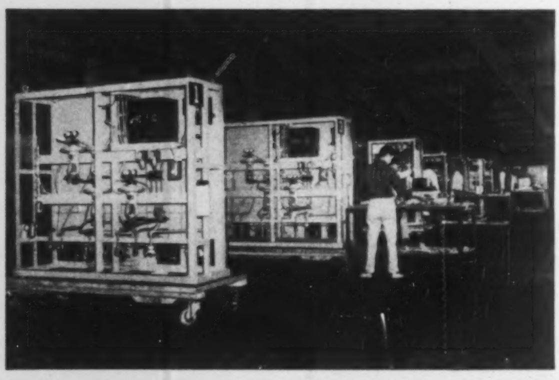

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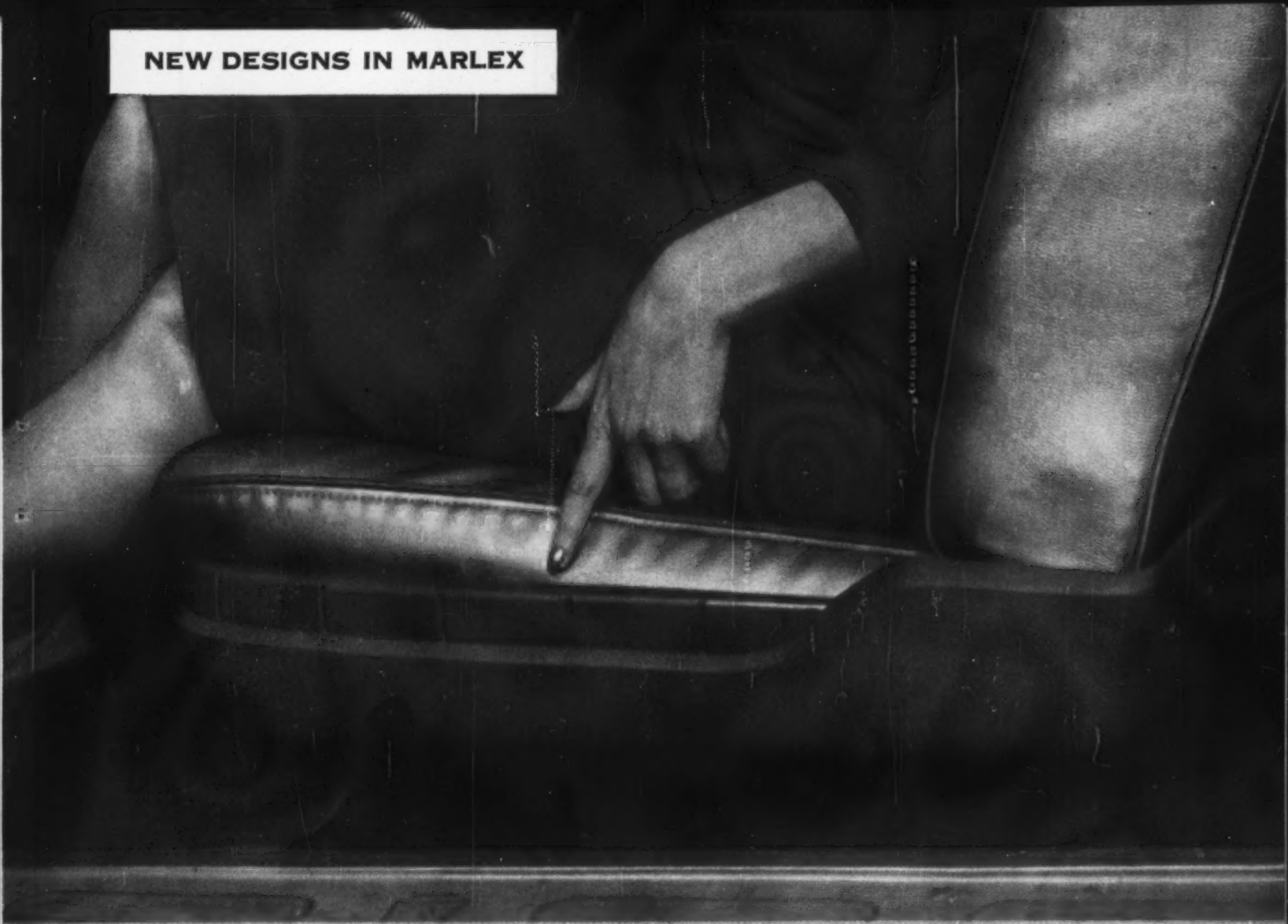

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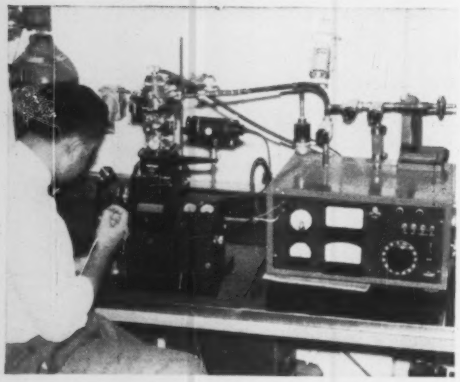
Cutting back the Thermal Thicket

The great strength and high scaling resistance of HAYNES alloys at temperatures of 2000+ deg. F. are providing long service life in the hottest areas of jet engines. Flame holders, flame steps and afterburners are some of the hot spots where the properties of HAYNES high-temperature alloys are helping combat burnout, erosion, and stress in the jet, ramjet, missile, and rocket fields.

There are twelve HAYNES high-temperature alloys to choose from, formulated to handle virtually any heat condition. Among them: HASTELLOY alloy X with remarkable resistance to oxidation up to 2200 deg. F. HAYNES alloy No. 25 that resists stresses, oxidation, and carburization up to 2000 deg. F. And HASTELLOY alloy R-235, outstanding in the 1500 to 1750 deg. F. range. All are readily available.



Solving high-temperature problems through research is part of Haynes Stellite's complete metallurgical services. This metallograph is used to observe metals at 2200 deg. F.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

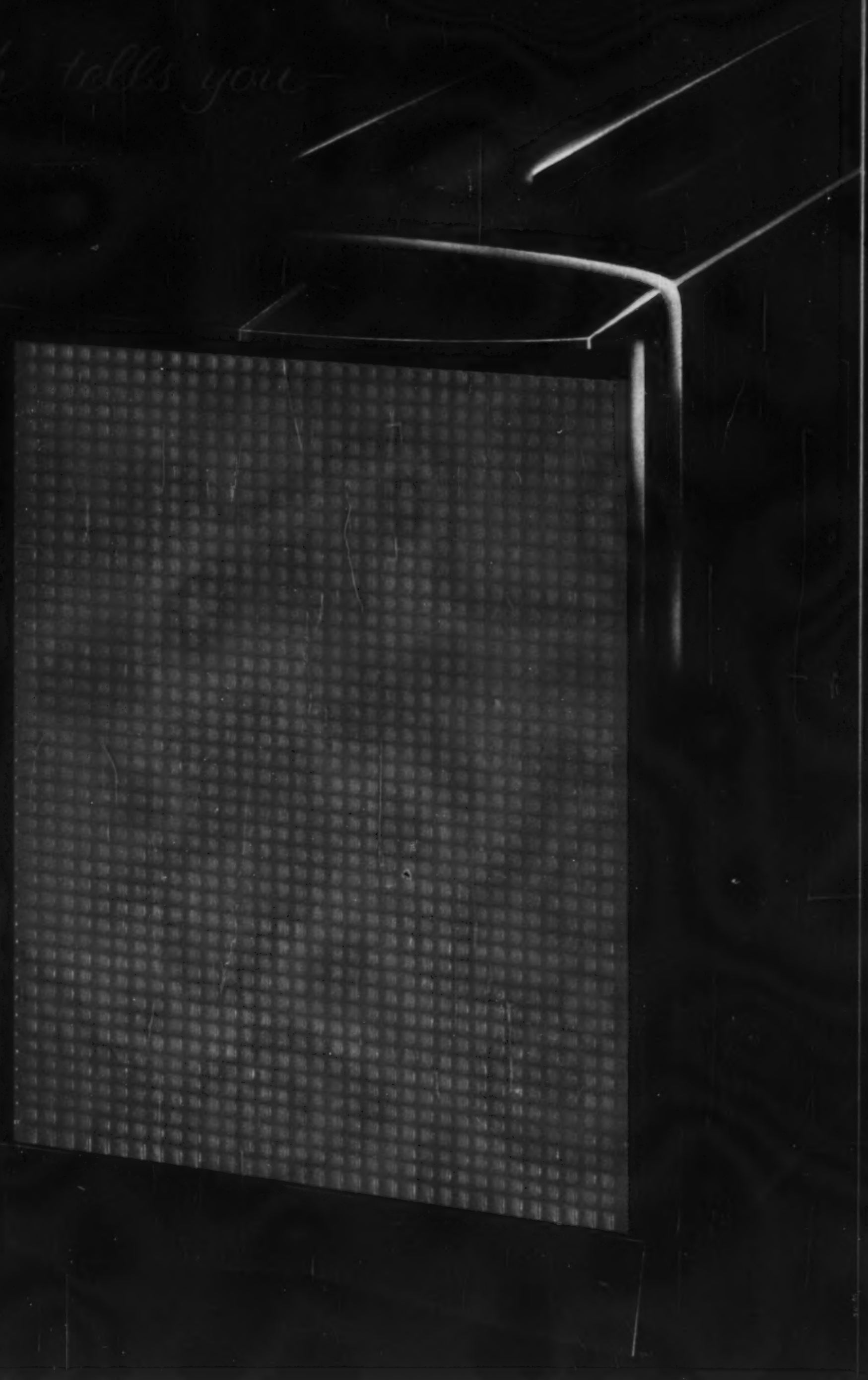
Address inquiries to Haynes Stellite Company, 420 Lexington Avenue, New York 17, N. Y.

"Haynes," "Hastelloy," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

For more information, turn to Reader Service card, circle No. 441

For more information, circle No. 444 ➤

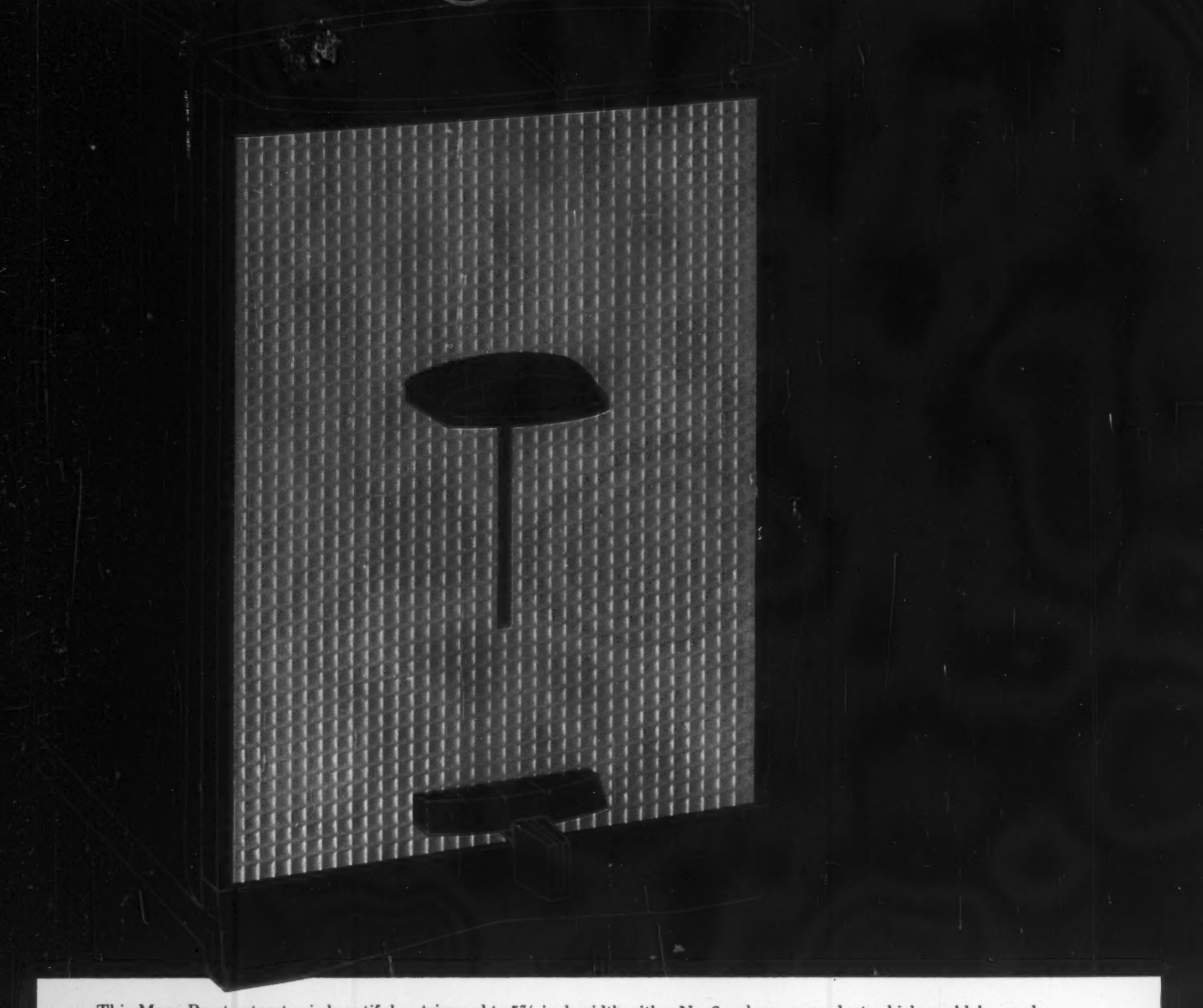
Just a touch tells you



how this
Mary Proctor
Toaster
took on new
sales
appeal

Gold-finished panels of USS American Embossed Amerstrip add richness, smart modernity to classic toaster lines

New Proctor Electric Company toaster styled by Raymond Loewy Associates has special design USS Embossed Amerstrip



This Mary Proctor toaster is beautiful—and different. On the sales counter it stands out from its competitors. Much of this sales-pulling distinction lies in the end panels formed from gold-finished, geometric-patterned Embossed Amerstrip. This effective pattern was created by famous industrial designers, Raymond Loewy Associates, and was rolled by American Steel & Wire.

The USS Embossed Amerstrip was given a No. 4 temper which is especially suitable for formulation work. It was rolled to .0239-inch thickness and trimmed to 5⅞-inch width with a No. 3 slit edge. So that the strip would make a good bond with the gold plate it was supplied with a No. 3 finish—the best finish available on strip. It is guaranteed against surface defects and has a sufficiently high lustre to make buffing or polishing before plating unnecessary. To protect the finish and the embossed design, the coils were interleaved with rolls of paper before shipping.

American Steel & Wire specializes in the rolling of special embossed designs for specific applications. If you have a product which could be made more beautiful or more sales-appealing with Embossed Amerstrip, get in touch with American Steel & Wire. Write to 614 Superior Avenue, N.W., Cleveland 13. Ohio. *USS and Amerstrip are registered trademarks*

USS

American Steel & Wire
Division of
United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
Tennessee Coal and Iron Division, Fairfield, Ala., Southern Distributors
United States Steel Export Company, Distributors Abroad

Is ALITE your answer to a tough design problem?

Some of the many shapes into which ALITE has been formed to solve difficult design and production problems for a wide range of products.

ALITE—the high-alumina ceramic developed by U. S. Stoneware—has superior properties which make it ideal for many highly critical applications. And it could well be that Alite is that "special material" you've been seeking to meet a particularly difficult design requirement.

Among the outstanding characteristics of Alite are its extreme hardness, high mechanical strength, vacuum tightness, zero water absorption, excellent resistance to abrasion, corrosion and nuclear radiation. The high temperature stability of Alite enables it to retain these properties at elevated temperatures (1300°C. to 1600°C. range). We can form Alite to virtually any shape, finish it to precision tolerances, metalize and braze it to metal components to produce high strength, hermetic Alite-to-metal seals. Pump pistons, sleeves, slide valves, seals, bearings and bushings are just a few possible mechanical applications for this versatile material. Alite's low dielectric loss characteristics are utilized in many electronic applications.

If your specifications call for a material with any of the properties Alite possesses, it may pay you to have our ceramics specialists study your requirements. Send us your drawings for our recommendations or quotation.

For complete technical data on Alite and Alite Ceramic-to-Metal Seals, write for Bulletins A-7R and A-40.

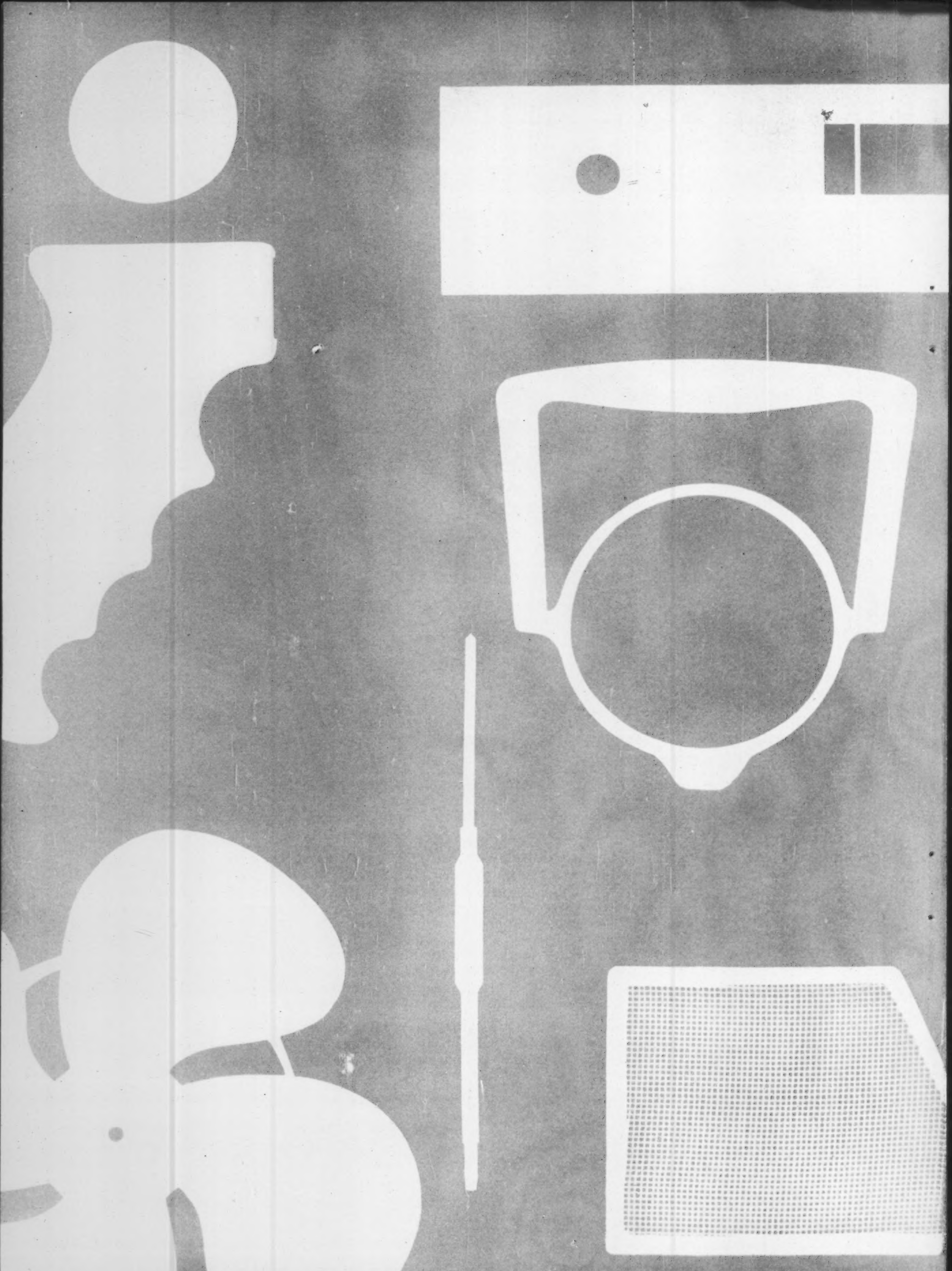
ALITE
HIGH ALUMINA
ALITE

69F-1

ALITE DIVISION

U. S. STONEWARE
AKRON 9, OHIO

For more information, turn to Reader Service card, circle No. 375

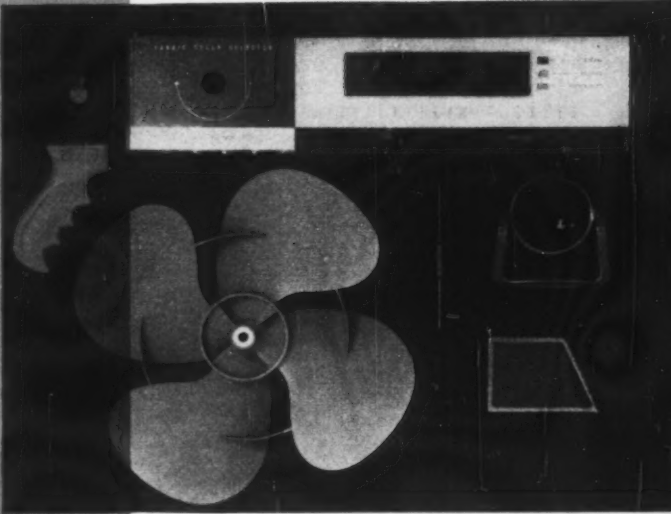


How the custom molder can help bring your product idea to life

The custom molder is well-known as a mass producer of molded plastics parts and products. But he is much more. Most helpful to the designer, the custom molder knows the design limits of the different plastics. He can recommend the best formulation for the job. He can also engineer the design to capitalize on the inherent advantages of plastics materials and the efficiencies of plastics manufacturing. His toolmakers build the master molds to the closest tolerances. His productive facilities can turn out plastics parts with unusually consistent quality, at rates to meet the tightest schedules and budgets.

Monsanto keeps the custom molder supplied with molding formulations of Monsanto Polyethylene, Lustrex® Styrene, and Opalon® Vinyl, specially developed and constantly perfected to meet a wide range of design requirements.

Which molding compounds to consider? Use the Plastics Properties Calculator, an easy-to-read slide rule that provides comparative property data on the many different plastics molding materials. For your free calculator, write to Monsanto Chemical Company, Plastics Division, Room 732, Springfield 2, Mass.

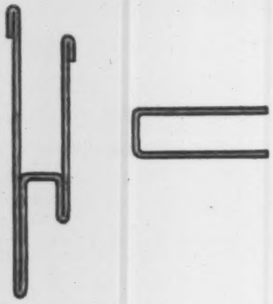


MONSANTO ACTIVATOR IN **PLASTICS**

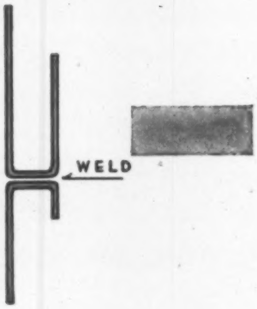
Monsanto®

For more information, circle No. 437

2 parts replace 3 and reduce assembly costs



These two Roll Formed Shapes replaced these three—two channels and a strip.



IN DESIGN

Product design created production problems. Solid strip was difficult to obtain. It was replaced by a Roll Formed U channel which weighs 55 % less. Many cut hands resulted from old channels. Hemmed edges on special Roll Formed shape eliminated this hazard. Dimensions are identical and structural strength is improved. Over-all appearance is decidedly improved.

IN PRODUCTION

Old assembly required 10 welds — 6 on channels and 4 in assembly. Roll Formed shape requires just 4 tack welds in assembly. One supplier and just two components permit deliveries keyed to production needs. Hemmed edges on H shapes eliminated cut hands on assembly line.

IN PURCHASING

Bookkeeping reduced by elimination of one item. Deliveries on time and keyed to production needs. Total costs on purchased items and assembly time were drastically reduced. Shipping weight reduced and net profit on the completed item was increased.

METALS AND TECHNIQUES

Your sections can be produced in: carbon, galvanized and stainless steel; aluminum, copper, zinc and clad metals. Tubing, shapes, channels and angles can be punched, notched, pierced, cut to length and delivered burr-free to match your production schedule.

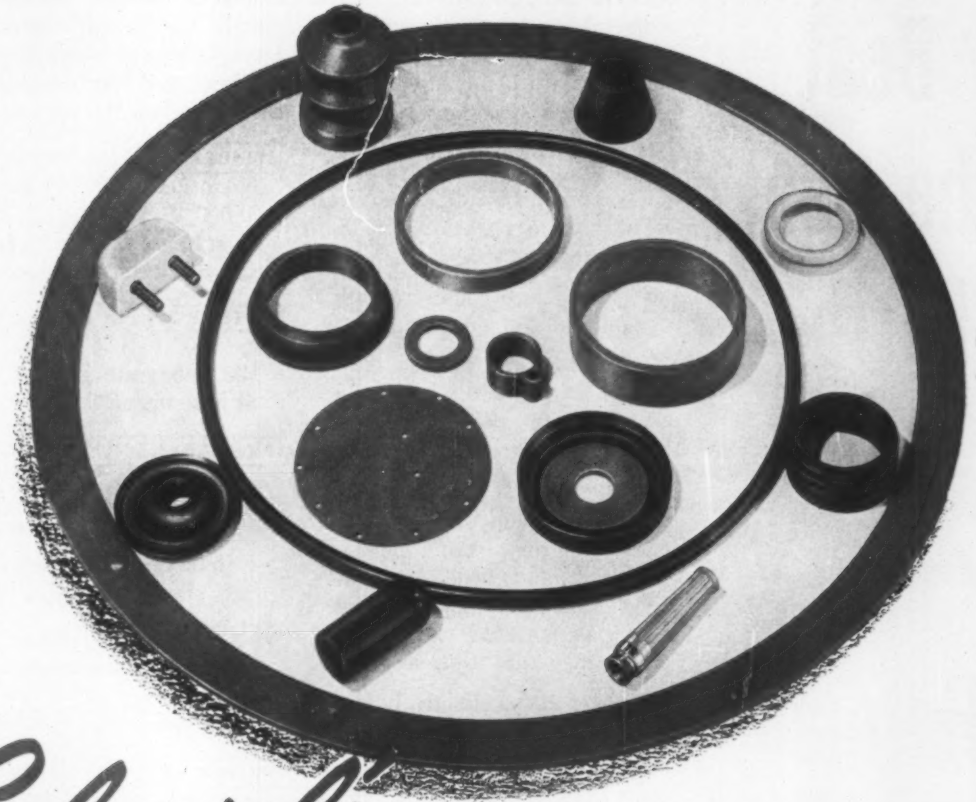
CAN ROLL FORMED HELP YOU?

Probably yes. The Roll Formed man can tell you. He'll go over your prints . . . work out an applicable section . . . plan deliveries with you. Meanwhile, you'll want Roll Formed Bulletin 1017. It shows how Roll Formed techniques give greater design freedom, increase production and help eliminate purchasing headaches. Get Bulletin 1017 today.

ROLL FORMED PRODUCTS
COMPANY

MAIN OFFICE AND PLANT • 3752 OAKWOOD AVE. • YOUNGSTOWN, OHIO

For more information, turn to Reader Service card, circle No. 381



Colonial's

"SILICOL"® SILICONE RUBBER

can improve your product and simplify fabrication problems

- ★ ***ANY MOLDED SHAPE***
- ★ ***ANY COMPOUND FORMULATION***

Colonial Rubber has a long record of achievement in using the unique properties of silicone rubber to meet "tough service" applications in all types of manufacturing. Particularly outstanding are the many special compounds our chemists have formulated to meet unusually rigid performance requirements in aircraft and missile applications.

In addition to the comprehensive industrial rubber technology we offer to help manufacturers solve rubber compounding problems. Colonial has large, modern and complete plant facilities to assure lower cost rubber molding and fabricating. We are *known* for our ability to meet manufacturer's "emergency" delivery requirements on priority projects.

Save time on your programs by sending prints and pertinent data on your *first* inquiry. We will promptly return an analysis and recommendations, together with illustrated information giving you complete details on our organization and its ability to serve you efficiently and economically.

1718-A

COLONIAL RUBBER CO.

706 Oakwood St.   AXminster 6-9611
RAVENNA, OHIO

For more information, turn to Reader Service card, circle No 374

Beat the Heat Barrier With Handy & Harman High Temperature Brazing Alloys!

Some of the problems of elevated temperature joint strength and oxidation resistance in heat-resistant alloys are being solved today by a relatively new group of Handy & Harman high temperature brazing alloys. These alloys embody certain unique characteristics, all of which are requisite for high temperature brazing:

- They have good strength and oxidation resistance at recommended temperatures.
- They are ductile, with the ability to withstand vibration and stress at elevated temperatures.
- These Handy & Harman alloys provide minimum solution and penetration of the metals being joined; this is a particular advantage when joining thin sections.
- These alloys effectively join stainless steels, low alloy steels, nickel-base alloys, cobalt-base alloys and other high temperature metals including refractory types.

The list of successful applications includes jet engine parts, heat exchangers, rocket motors, clad metals, honeycomb structures, turbine blades and many others. The following are brief descriptions of these Handy & Harman alloys:

LITHOBRAZE 925 For short time operation to 900° F, continuous at 500° F. Very ductile, virtually no solution of base metal. Good salt-spray corrosion resistance.

HI-TEMP 30 For continuous service 900° F-1000° F. Fairly ductile, moderate general solution of base metal.

PREMABRAZE 128 Continuous service up to 1500° F. Ductile, moderate solution of the base metal. Tensile strength at 1600° F in 304 stainless steel is 20,000 psi (short time test).

PREMABRAZE 130 Same properties as PREMABRAZE 128, but freer flowing and lower brazing temperature.

PREMABRAZE 101 Continuous operation in 1800° F-2000° F range (based upon limited oxidation tests). Ductile, moderate solution and penetration of the base metal.

Alloy	Nominal Composition	mp° F	fp° F
LITHOBRAZE 925	92.5 Ag 7.3 Cu .2 Li	1435	1635
HI-TEMP 30	70 Mn 30 Ni	1885	1920
PREMABRAZE 128	72 Au 22 Ni 6 Cr	1785	1900
PREMABRAZE 130	82 Au 18 Ni	1740	1740
PREMABRAZE 101	54 Pd 36 Ni 10 Cr	2250	2300

Data sheets and complete details on each of the above Handy & Harman alloys are available upon request to Handy & Harman, 82 Fulton Street, New York 38, N. Y.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN QUALITY SERVICE

HANDY & HARMAN
General Offices: 82 Fulton St., New York 38, N. Y.
DISTRIBUTORS IN PRINCIPAL CITIES

OFFICES AND PLANTS
BRIDGEPORT, CONN.
PROVIDENCE, R. I.
CHICAGO, ILL.
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LOS ANGELES, CALIF.
OAKLAND, CALIF.
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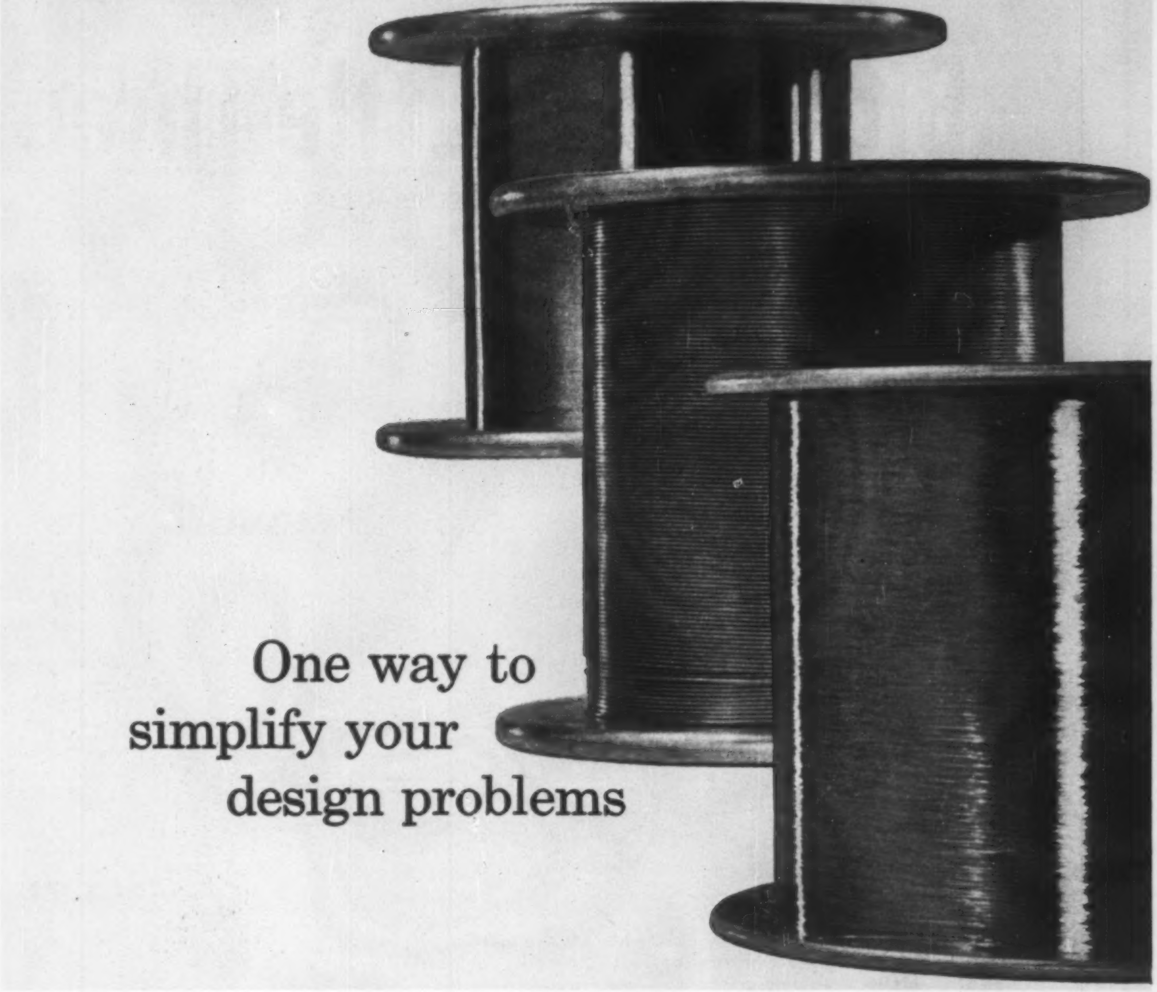
SYLVANIA MAKES ALL THREE—ALLOY, CLAD AND PLATED WIRE



One way to simplify your design problems

—let Sylvania give you an unbiased recommendation on wire

In today's designs for high-temperature products, this much is clear: wide variations in corrosion- and oxidation-resistance plus conductivity make wire selection all-important.

You can simplify your design and specification problems by getting a Sylvania recommendation on wire. Sylvania knows wire, knows the particular advantages of each kind. In fact, of all major manufacturers, only Sylvania makes all three types of bare wire—alloy, clad and plated. Available in a complete range of sizes—.002 to .250, retains optimum characteristics at temperatures up to 1600° F.

Thus you can be sure a Sylvania wire recommendation will be objective—it will be based on your needs, and not limited by what the supplier can supply. Why not get full details and timesaving technical assistance today. Simply write Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.

SYLVANIA

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

For more information, turn to Reader Service card, circle No. 436

Big Three's Little Three
to get Greater Strength
for Maximum
Corvair
Falcon

Each time a trio of these new cars rolls off the assembly lines at Ford, Chrysler Corporation and Chevrolet, another set of 67 Malleable parts goes into action to give American drivers more dependability, convenience and economy.

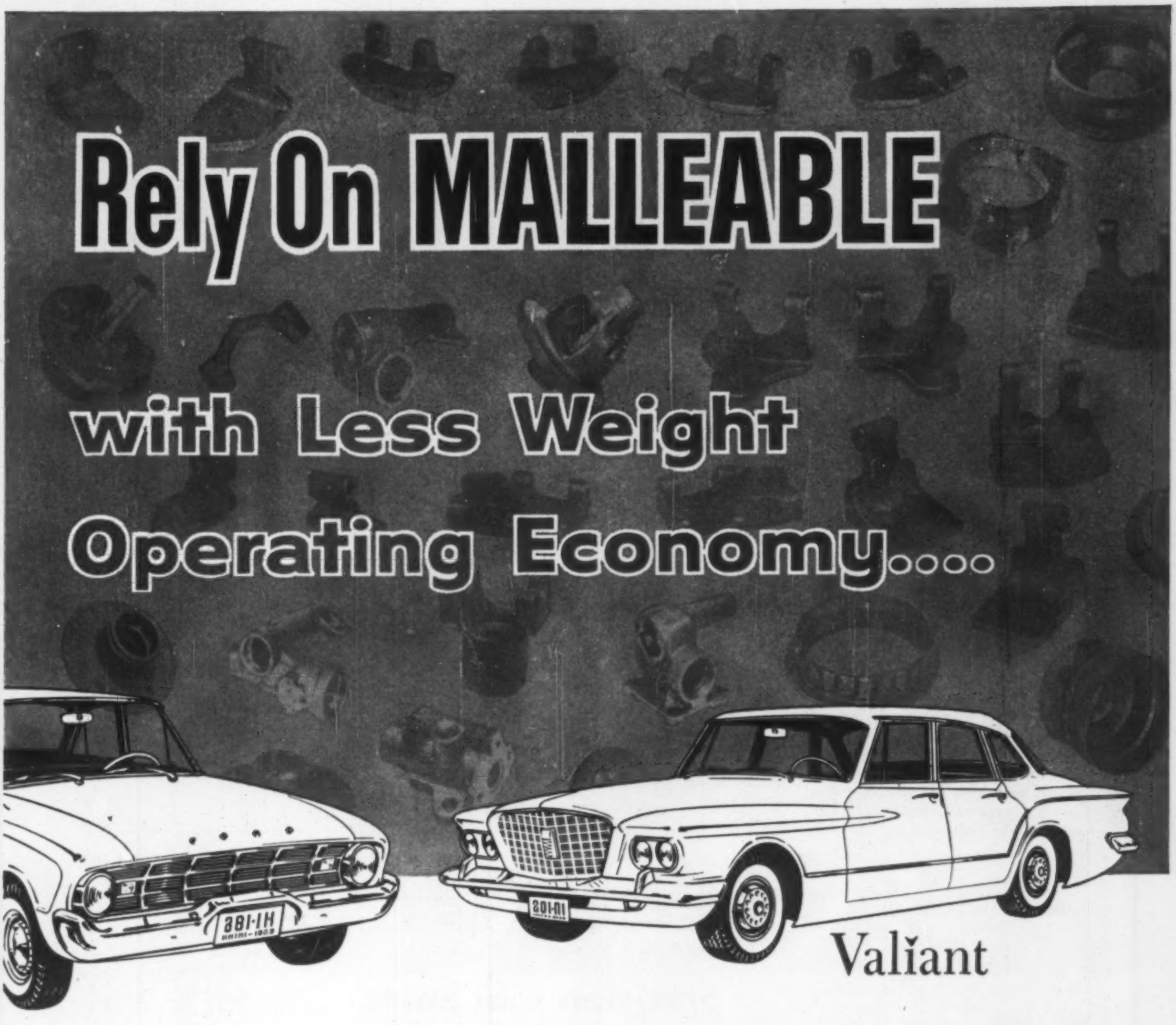
Valiant, Corvair and Falcon Use Greater Proportions of Malleable Iron Than the Three Conventional Cars!

Brand new from tread up, the Corvair, Falcon and Valiant are the result of intensive investigation, engineering and testing . . . all done to produce lighter, more economical cars without sacrificing the safety and convenience demanded by the American public.

To accomplish this, the automobile industry's

These companies are members of the MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4
DELAWARE
Eastern Malleable Iron Co., Wilmington 99
ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur
INDIANA
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22
IOWA
Iowa Malleable Iron Co., Fairfield
MASSACHUSETTS
Belcher Malleable Iron Co., Easton



three newest creations use *more* Malleable in proportion to total materials than all other models of the same manufacturers. Why? Malleable provides *more strength per dollar* than any other metal, ferrous or non-ferrous. Malleable castings have *more strength per pound* than "light" metals. Being the *most machinable of all ferrous metals* of similar properties, Malleable speeds production . . . produces better parts. Malleable castings have proved uniquely dependable for critical applications in millions of cars now on the highways.

How many places are there in your operations where Malleable castings can improve your products and reduce your costs? Check now . . . send drawings or an outline of your requirements to any of the progressive Malleable castings producers who display this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

Union Commerce Building, Cleveland 14, Ohio

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw
MINNESOTA
Northern Malleable Iron Co., St. Paul 6
NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia
NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland
OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6
PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster
TEXAS
Texas Foundries, Inc., Lufkin
WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant
WISCONSIN
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

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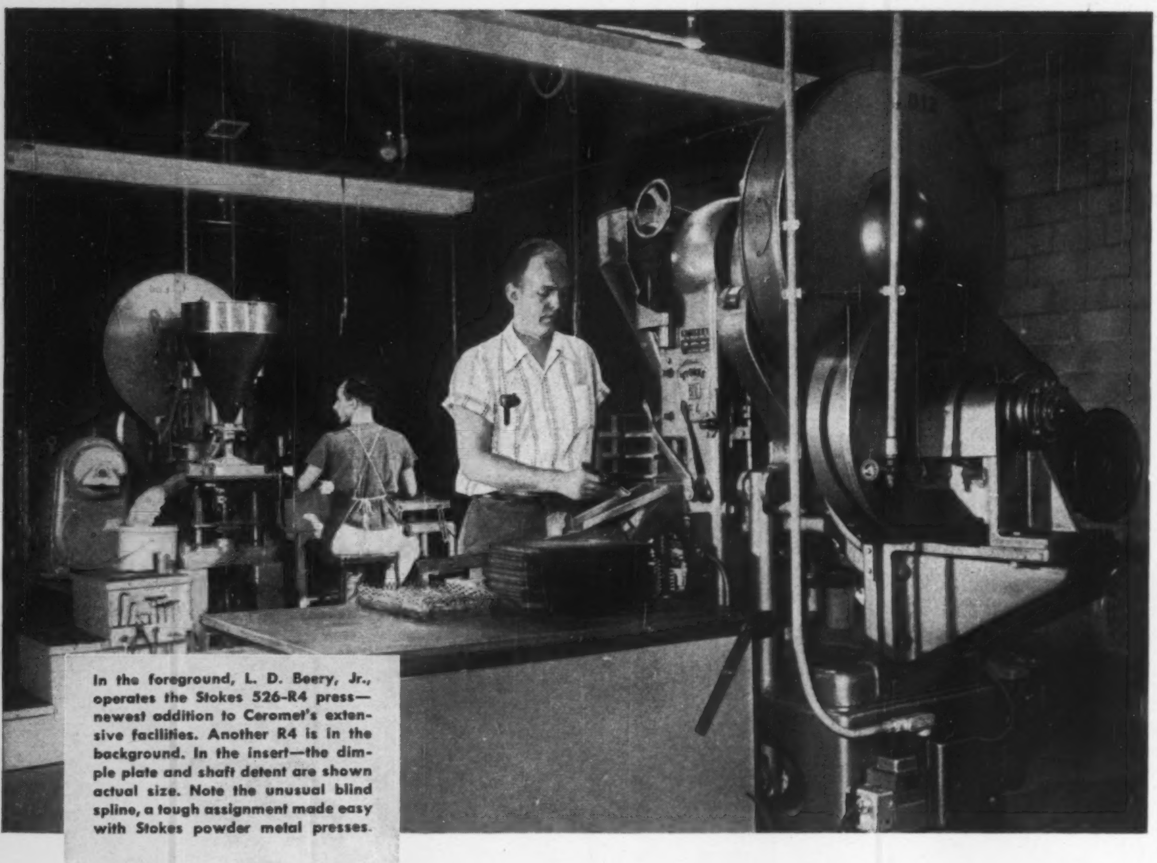
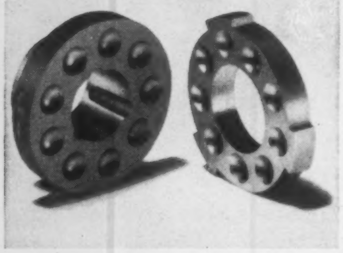


In the foreground, L. D. Beery, Jr., operates the Stokes 526-R4 press—newest addition to Ceromet's extensive facilities. Another R4 is in the background. In the insert—the dimple plate and shaft detent are shown actual size. Note the unusual blind spline, a tough assignment made easy with Stokes powder metal presses.



CEROMET INC., cuts precision tool parts costs 60% with STOKES POWDER METAL PRESSES

Ceromet Inc., La Puente, California manufacturer of powdered metal products, makes dimple plates and shaft detents for a major West Coast precision tool company. The combination of sintered metal and Stokes compacting presses were chosen for this job to provide fast, economical production of quality, close-tolerance parts. Both pieces are produced at the rate of 25 per minute, sintered in a dissociated ammonia atmosphere, and case hardened .020″ in a carbo-nitriding furnace.

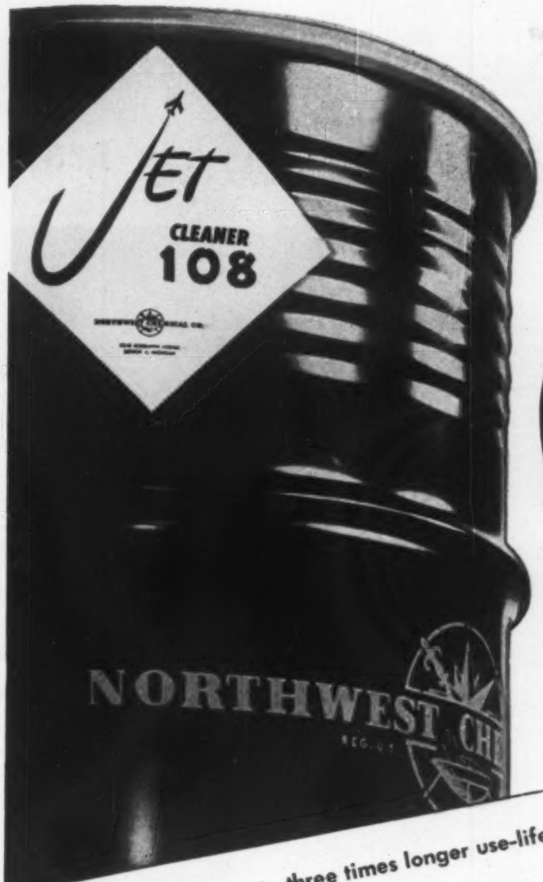
Stokes industrial compacting presses produce these parts at an estimated 60% cost reduction over machining—make possible the production of efficient designs not even possible by older and costlier methods. The reproducibility of dimensional control is within 1%—thanks to powder metallurgy techniques and Stokes precision equipment.

Stokes Engineering Advisory Service will be glad to consult on your specific powder metal applications—to help design parts, punches and dies, or complete production facilities. Additional technical information on the entire Stokes line of industrial compacting presses will be sent you on request.

Powder Metal Press Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

For more information, turn to Reader Service card, circle No. 350



ANNOUNCING

JET 108

AN EXTREMELY LOW-FOAMING GENERAL USE SINGLE OR MULTIPLE STAGE SPRAY CLEANER FOR BETTER RESULTS AT LOWER COST!

- Gives up to three times longer use-life than competitive products.
- Better cleaning through unusually potent penetrants, surfactants and dispersing agents.
- Carries heavy dirt load without redeposition.
- Higher the concentration, lower the foaming.
- For use on all ferrous and non-ferrous metals except aluminum.
- Used at 100° to 140°F temperatures.
- Easily removes drawing compounds, oils, and greases.
- An effective rust-inhibitor for in-plant use.
- Ideal for use following soak cleaners.
- An easily handled, moist, granular alkali base material.
- Non-Toxic, dustless, non-caking.
- No disposal problem.

Got a problem? Let Northwest's Cleaning Specialists help you.

Licensed Manufacturers { Alert Supply Co., Los Angeles, California
Armalite Company, Ltd., Toronto, Canada

NORTHWEST CHEMICAL COMPANY
9310 ROSELAWN DETROIT 4, MICHIGAN

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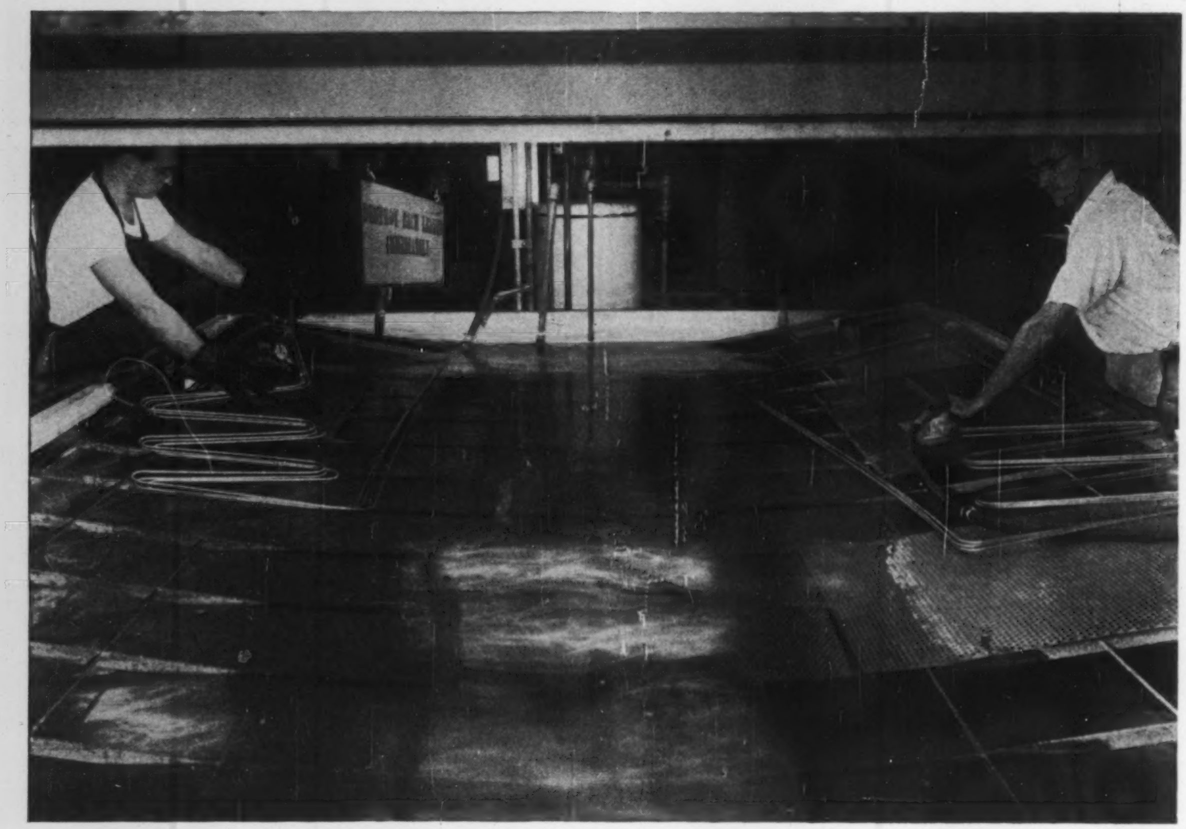
THE PEOPLE WHO KNOW REFRIGERATION BEST DEPEND ON THE PEOPLE WHO KNOW TUBING BEST!



THE CLEANEST TUBING YOU CAN BUY... UNDER PRESSURE EVERY INCH OF THE WAY!

Every inch of GM Steel Tubing is pressure-tested and cleaned. Solvent is introduced under pressure to all bulk coils, checking structural strength and assuring an I.D. free of internal residue. Then after your specifications take shape—as in the serpentines above—they are again tested under pressure to assure a clean, leak-proof tubing that will stand up under the most rigid conditions for the life of your product. Call a GM Steel Tubing Sales Engineer today. Put some of this top-quality tubing on test now. See how you can save time and money with the cleanest tubing you can buy. *Rochester Products Division of General Motors, Rochester, New York.*

GM STEEL TUBING BY ROCHESTER PRODUCTS

RP

AMERICA'S LARGEST MANUFACTURER OF REFRIGERATION TUBING

For more information, turn to Reader Service card, circle No. 369

NEW FROM C/R
SIRVON

Chicago Rawhide's family of high temperature chemically resistive materials that will seal almost anything, resist almost everything!

The brand name Sirvon represents any of several broad temperature range materials that are virtually inert, chemically . . . such as "TFE"* resins, Kel-F† resins, etc. However, there is an important difference in Sirvon. C/R compounders have dramatically improved the physical properties by blending with certain additives, and by the development of special production techniques. Here, briefly are a few typical properties:

TEMPERATURE RANGE: -320° to 500° F.

CHEMICAL RESISTANCE: Inert to all fluids and gases except flourine and molten alkali metals.

FRICTIONAL VALUES: Coefficients of friction as low as .016 (static) and 0.04 (dynamic).

SHORE DUROMETER: From 55 to 73 (D Scale) depending on additive material used.

ABRASION RESISTANCE: Dry bearing test — as little as 0.00005 in. per million rpm on ½-in. shaft. Temperature 100° F.; rpm 156; bearing pressure 120 psi.

The practical solutions to many design problems may be found with these new, specially compounded materials. If you are looking for shaft seals, sealing rings, bearings, packings or gaskets that require unusually low friction, extreme temperature and chemical resistance, consult with C/R sales engineers.

Write for C/R Sirvon Bulletin SR-101 for more information on properties and applications.

CHICAGO RAWHIDE MANUFACTURING COMPANY

SIRVON DIVISION: 1227 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York

C/R Products: C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts
Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears.

*DuPont Reg. T.M.,
†Reg. T.M. M. W. Kellogg Co.

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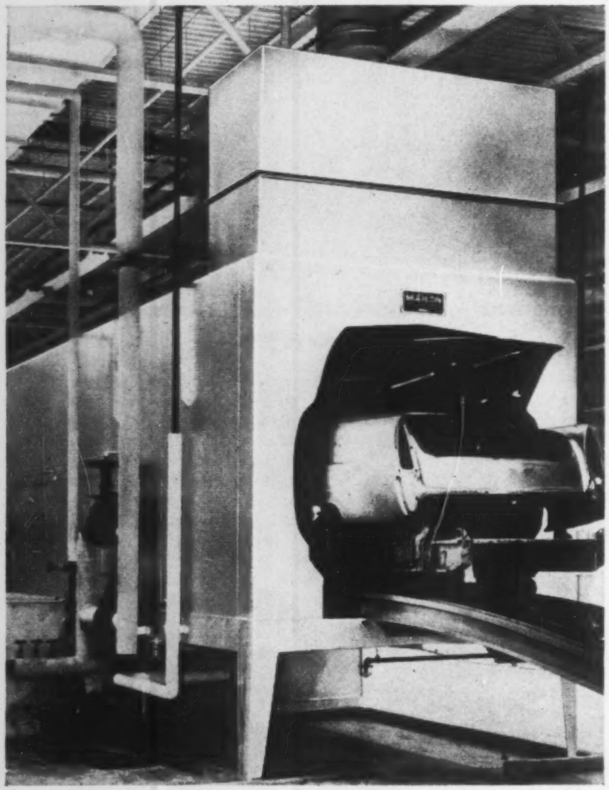
Cold Bonderite systems produce

auto
sav



in your

You can't help cashing in when you have a Cold Bonderite System working for you. The difference in heat required shows up at once as a reduction in operating costs.

You operate cleaner, rinse and Bonderite 40° to 75° cooler than in conventional phosphating installations. Automatically, fuel costs go down!

There are other automatic savings built into Cold Bonderite: reductions in water use, less consumption of electrical power and elimination of exhaust and ventilating equipment. Servicing and maintenance are quicker and easier, too, saving labor and downtime.

All these add up to important money savings—thousands of dollars a year in

Since 1914— leader in the field

matic
ings
phosphating line!

large installations, proportionately great in smaller plants.

Complete line of Cold Bonderite Systems

You aren't limited to a single type of phosphate coating in choosing your Cold Bonderite System. Parker has cold iron phosphates, cold zinc phosphates, and products for low temperature 3-stage production washers. And spray or immersion applications are available.

Cold Bonderite chemicals come to you in safe liquid form, for easy build-up and replenishing and to insure against operator error in maintaining most efficient chemical balance for continuous operation.

These chemicals have built-in accelerators for *fastest* coating action and are exclusively formulated to meet the requirements of today's production lines.

Highest quality coatings

Results produced by Cold Bonderite Systems equal the highest quality Bonderite standards. Chemical costs are as economical as conventional "hot" phosphating systems so all savings go right into profits. There are no changes in equipment needed, no new techniques to teach your crew.

With no trouble at all, you can make the switch from hot phosphating to a Cold Bonderite System—and start automatic savings right away!

Call in the Parker man now!

Parker Rust Proof Company

2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base	BONDERITE and BONDERLUBE aids in cold forming of metals	PARCO COMPOUND rust resistant	PARCO LUBRITE—wear resistant for friction surfaces	TROPICAL—heavy duty maintenance paints since 1883

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

For more information, turn to Reader Service card, circle No. 339

TALL ORDER!

ACIPCO 50-FT. MANDREL GIVES LONGER LIFE IN EXACTING APPLICATION

Completely fabricated and machined by ACIPCO, this 50-foot mandrel is giving longer, more durable service to an outstanding producer of power transmission poles, light standards, and other similar equipment. These products are produced by hydraulically forming steel plate around the mandrel.

Type 4330 alloy steel, heat treated to 300 minimum Brinell hardness for wear resistance and strength, was selected for this application. The mandrel—consisting of four ACIPCO centrifugally spun tubes threaded and screwed together—is 24″ in diameter with a 3″ wall and is provided with a 0°20′20″ taper from end to end. The O. D. is finish machined and belt polished to a 125 micro-inch finish to facilitate stripping the poles from the mandrel.

This is another example of ACIPCO versatility in action . . . of how ACIPCO'S wide range of sizes and analyses, and "one source—from start to finish" facilities can solve a complicated steel tubing problem, including YOURS!

ACIPCO
SPECIAL PRODUCTS
DIVISION OF ACIPCO **AMERICAN CAST IRON PIPE CO.**
BIRMINGHAM • ALABAMA

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1000
900
800
700
600
500
400
300
200
100

in this zone, stainless steels that remain ductile with high strength and stability

In the search for favorable strength-to-weight ratio, high temperature alloys have been developed with extreme strength up to 1000 F, but at the expense of ductility.

In AM 350 and AM 355, Allegheny Ludlum's precipitation hardening stainless steels, you have high hardness and stability from room temperature to 1000 F, plus almost twice the ductility!

These advantages are followed by easy formability using normal techniques. AM 350 and AM 355 can be brazed and welded as easily as the common stainless steels. They can be spun, formed and machined without special preparation.

AM 350 is available commercially in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." **Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Penna.**

651

ALLEGHENY LUDLUM

A-L

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

For more information, turn to Reader Service card, circle No. 431

Yoder Rotary Slitters reduce inventory... speed production

To help meet the demands of tight production schedules, YODER Slitters reduce mill-width stock quickly and economically to desired widths. If your needs are as low as 100 tons per month, time and manpower savings alone will offset the cost of your YODER Slitter in a matter of months, while reducing basic inventories. Compactly designed, standard YODER Slitters are built to handle standard coil widths...completely engineered lines for special requirements.

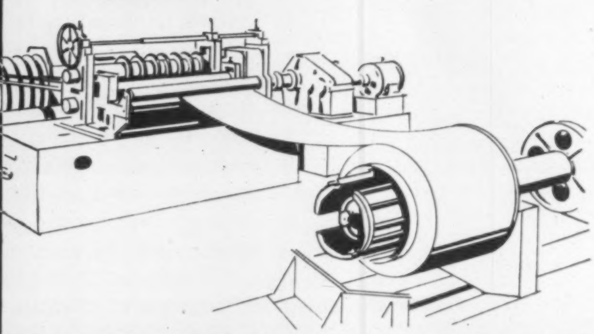
YODER accessories, such as coil cars, swivel unloaders, scrap choppers, scrap disposers, plate levelers and coil boxes, make stock handling fast and easy.

YODER also makes a complete line of Cold Roll-Forming equipment and Pipe and Tube Mills. To profit from YODER'S years of engineering and service experience, contact your local YODER representative or send for the YODER Slitter Manual.

THE YODER COMPANY
5546 Walworth Avenue • • Cleveland 1, Ohio

SLITTING EQUIPMENT
YODER

Investigate the many advantages of YODER-engineered Slitter Installations. Write today for this comprehensive, 80 page YODER Slitter Manual ... it's yours for the asking!



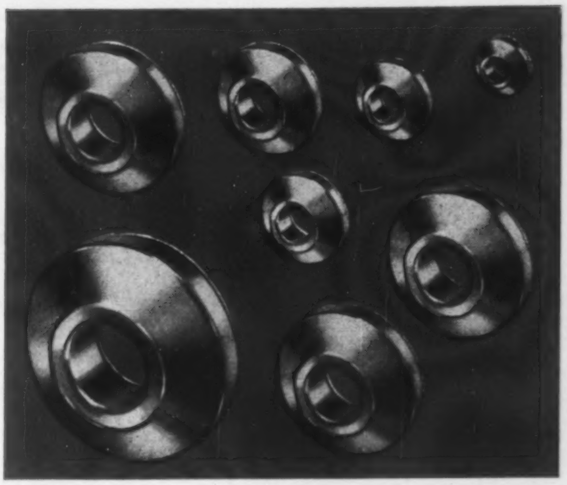
ENGINEERING
YODER
MANUFACTURING

ROTARY SLITTING LINES
PIPE AND TUBE MILLS (ferrous or non-ferrous)
COLD ROLL FORMING MACHINES

For more information, turn to Reader Service card, circle No. 397

35 MILLION BEARINGS...

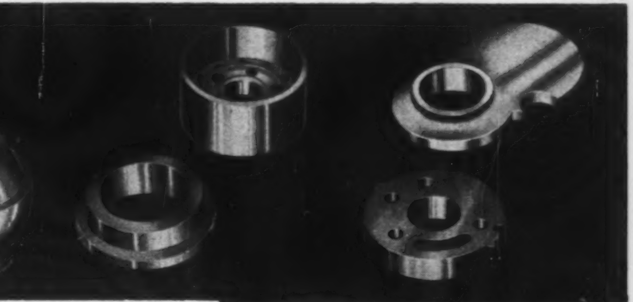
and every one has given perfect performance! that's the record of GRAMIX® bearings in the famous TAYLOR-TOT® SLEEPER WALKER-STROLLER



Where there are youngsters, there are Taylor-Tots . . . and where there are these familiar sleeper walker-strollers there are GRAMIX bearings . . . in fact, 35 million to date have been shipped to the Frank F. Taylor Company of Cincinnati and have been accepted by their receiving inspection department without a single rejection. The strength, durability and resistance to wear of these GRAMIX bearings, two of which are used in each wheel, help give Taylor-Tot easier steering and handling. Even though Taylor-Tot strollers are run through snow, dirt and many times are left out in adverse weather, GRAMIX bearings provide the maximum in quietness, free running and long life.

GRAMIX is the ideal bearing material because it can be oil-impregnated for self-lubrication, requires no machining and is completely dependable.

273



If you are not already using GRAMIX in your products, it will pay you to consult our engineers . . . to discover how you can benefit from the high quality . . . low cost . . . top performance of GRAMIX products of powder metallurgy.

Write today for Engineering Bulletin No. 18, which covers design and metallurgical requirements and alloy selection of GRAMIX bearings. ▶

GRAMIX BEARINGS

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

For more information, turn to Reader Service card, circle No. 378

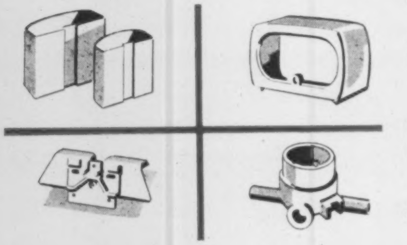
Thermaflow® Tips

News about high-strength molding compounds

Atlas Powder Company, Wilmington 99, Delaware
In Canada: Atlas Powder Company, Canada, Ltd., Brantford, Ont.

New Thermaflow 105 saves 20% over other high-strength plastics

If you've been interested in using high-strength plastics in products now made of metal or conventional plastics—but found the price tag too steep . . . here's news. New Thermaflow 105 reinforced polyester premix gives you a balance of strength, moldability, surface finish, chemical and electrical properties—at a cost about 20% lower than other high-strength compounds. It's the best buy yet in terms of strength per dollar.



An "idea" material

This new combination of performance and price opens up endless new design possibilities. Use it for new quality and economy in TV and radio cabinets, air conditioner housings, appliance parts, instrument cases, tubes, buckets, panels, tanks. You name it . . . we'll help you do it.

Take a look at the characteristics listed here. Remember—you'll get maximum benefits when you design to utilize its high-strength, corrosion resistance, and consistently high quality to the utmost. It's easy to use, too . . . pulls apart readily to load in molds, and has long stability in storage.

MOLDED PROPERTIES

Specific gravity	1.87
Flexural strength, psi	
*ASTM bar	20,000
**Cut specimen	16,000
Flexural modulus (psi x 10^6)	1.6
Izod impact-notched, ft./lbs./in. notch	
*ASTM bar	12.0
**Cut specimen	4.5
Compressive strength, psi	18,000
Heat distortion point, 264 psi	$>$450° F.
Barcol hardness	65
Water absorption, %	
24 hours @ 23° C.	0.14%
24 hours @ 100° C.	0.75%

*ASTM bar—Test results achieved with a sample molded under ideal laboratory conditions to achieve maximum strength.

**Cut specimen—Test results achieved on a number of samples cut from molded parts at random direction to any possible glass alignment. Results reported are the average of several tests.

NOTE: Common practice reports test results in terms of the maximum values available under ideal conditions "ASTM bar" figures are listed here to permit comparison of Thermaflow 105 with other similarly reported materials.

ELECTRICAL PROPERTIES

Arc resistance, sec.	130 sec.
Dielectric strength (⅛" thick)	
v/mil short time	230 v/m
step by step	210 v/m
Dielectric constant (1 mc.)	5.05
Dissipation factor (1 mc.)	0.009

STRENGTH RETENTION

	Flexural Strength, psi	Flexural Modulus x 10^6	Appearance
Original sample	16,000	1.58	—
24 hours	After Test	After Test	
H_2O @ 100° C.	13,400	1.21	excellent
24 hours 10% boiling NaOH	13,800	1.09	good
24 hours 10% boiling HCl	10,500	0.87	surface good—pigment bleached white

Price Schedule (f.o.b. Wilmington; Net 30 days)
Standard Colors: grey, tan, black

1 carton — (80 lbs.)	— $ .64/lb.
5 cartons — (400 lbs.)	— .48/lb.
24 cartons — (1,920 lbs.)	— .42/lb.
120 cartons — (9,600 lbs.)	— .41/lb.
252 cartons — (20,160 lbs.)	— .40/lb.
less than 1 carton	— 1.00/lb.

Get full facts today—

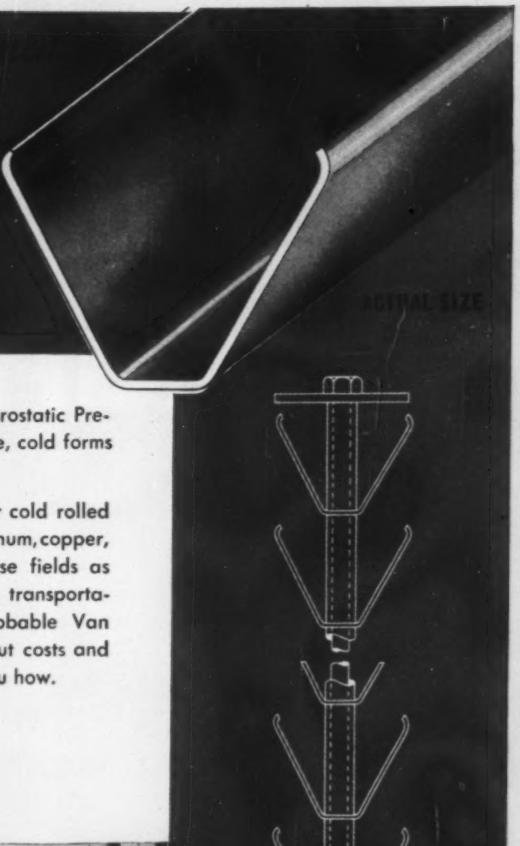
Write for catalog of Thermaflow materials, and for case histories of their use by leading molders.

For more information, turn to Reader Service card, circle No. 357

another idea roller die cold formed

by **VAN HUFFEL**

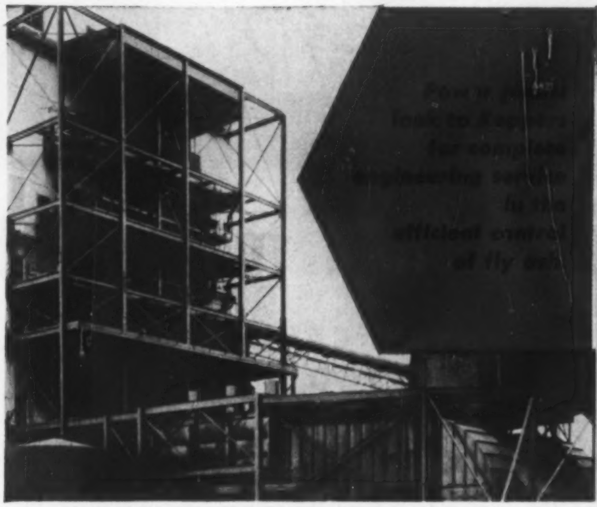
FOR KOPPERS ELECTROSTATIC PRECIPITATORS

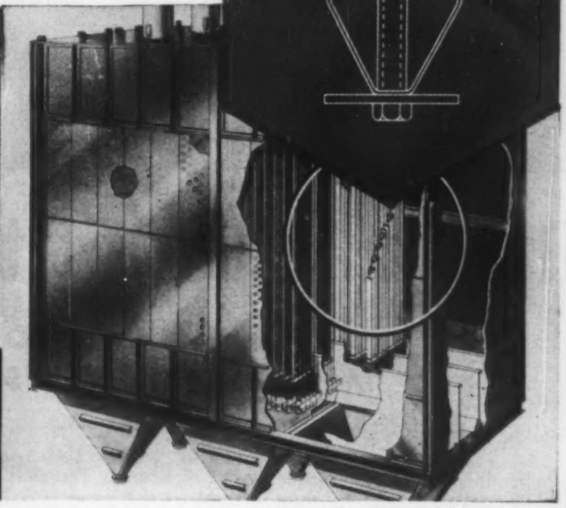

ACTUAL SIZE

This V-Pocket Electrode section, produced for Koppers Electrostatic Precipitators, is another of the many ideas Van Huffel roller die, cold forms in various metals for a wide variety of applications.

Whether you require a simple or complex shape—in hot or cold rolled steel, stainless steel, high strength steel, coated steel, aluminum, copper, painted or plated metals—for parts in such widely diverse fields as material handling, building construction, communications, transportation, farm implements, furniture and appliances—it's probable Van Huffel's experience, facilities and products can help you cut costs and make a better product. The handbook shown below tells you how.

Where ideas take shape


Power plants look to Koppers for complete engineering service in the efficient control of fly ash



van huffel
roller die
cold formed
metal
shapes

MAIL COUPON FOR FREE METAL SHAPES HANDBOOK . . .

48 fact filled pages on material selection, fabrication methods, tolerances and dozens of illustrated ideas that have taken shape in metal.

Name .... Title ....

Company ....

Address ....

City............................Zone....State ....

VAN HUFFEL TUBE CORPORATION • WARREN, OHIO

For more information, turn to Reader Service card, circle No. 362

Revere helps "fit the metal to the job"

AND A MAKER OF MEDICINE CABINET MIRROR FRAMES SAVES $10,000 A YEAR

As a result of a suggestion made by one of Revere's Technical Advisors, a maker of mirror frames for medicine cabinets has saved $10,000 a year on polishing costs alone. The suggestion was that, by changing to a brass of different grain size, the manufacturer might be able to save money on polishing costs and at the same time improve the quality of his product. (The 90° bend to which the mirror frames are subjected also had to be taken into consideration.)

Samples were made using a Revere Brass Strip with a smaller grain size as recommended by the Technical Advisor. Tests showed that, as a result of the change the manufacturer was able to realize a saving of 17¢ per mirror frame on polishing costs alone, with no increased costs in other operations, including the 90° bend. Based on the saving per frame this manufacturer has saved $10,000 per year for the past 4 years!

Here is still another example of how Revere's Technical Advisory Service working with the customer and the mill helped "fit the metal to the job," thus saving the customer money as well as improving product quality.

Why don't you take advantage of the extensive knowledge of Revere's Technical Advisory Service in "fitting the metal to the job?" It's entirely possible this service can save you money . . . help improve the quality of *your* product.

REVERE COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
Executive Offices: 230 Park Avenue, New York 17, N. Y.

Mills: Rome, N. Y.; Baltimore, Md.; Chicago, Clinton, Ill.; Detroit, Mich.; Los Angeles, Riverside and Santa Ana, Calif.; New Bedford, Mass.; Brooklyn, N. Y.; Newport, Ark.; Fort Calhoun, Neb. Sales Offices in Principal Cities, Distributors Everywhere.

For more information, turn to Reader Service card, circle No. 416

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Quenching and Tempering Alloy Steels

Of the various methods of heat-treating alloy steels, one of considerable importance is that involving quenching and tempering. This method, which enhances the mechanical properties of the end product, differs materially from normalizing and annealing (previously discussed in this series).

The purpose of quenching is to effect a cooling rate sufficient to develop the desired hardness and structure.

Before quenching takes place, steel is heated to a point above the transformation range. Quenching is the subsequent immersion of this heated steel in a circulated or agitated bath of oil, water, brine, or caustic; or, in the case of austempering or martempering, generally in agitated molten salt baths at a prescribed temperature. Austempering and martempering are preferable where a minimum of distortion is desired.

Quenching *increases* the tensile strength, yield point, and hardness of alloy steels. It *decreases* ductility—that is, elongation and reduction of area. It also decreases resistance to impact. However, by means of tempering, it is possible to restore some of the ductility and impact-resistance—but only at a sacrifice of tensile strength, yield point, and hardness.

The results of mild oil- or water-quenching as related to mass effect can be found in the end-quench hardenability test. Voluminous data concerning this test are issued by AISI and SAE in the form of hardenability bands for the various grades of alloy steels.

If thermal cracking is to be avoided, cooling by liquid quenching should not be carried to a point below 150 deg F. When a temperature of 150 deg F is approached, immediate tempering should follow. Because of residual stresses, no steel should be used in the as-quenched condition.

Tempering can be defined as reheating to a specified temperature below the lower critical range, followed by air cooling. It can be done in furnaces, oil, or salt baths, the temperatures varying from 300 to 1200 deg F. With most grades of alloy steel, it is best to avoid temperatures between 500 and 700 deg because of the "blue brittleness" that occurs in this range. Maximum hardness and wear-resistance result from tempering at low temperatures; maximum toughness is achieved by tempering at the higher levels. Of course, one of the essential reasons for tempering is to relieve the residual stresses set up in quenching.

Bethlehem metallurgists have devoted years of study to all phases of heat-treating. By all means call them if they can be of service to you. And please remember, when you are next in the market for alloy steels, that Bethlehem makes all AISI standard grades, as well as special-analysis steels and the full range of carbon grades.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

Export Distributor:
Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 365

VINYL METAL LAMINATES IN DESIGN

CLAD REX

The Broad Effect of Clad-Rex® on manufacturing methods and costs

Reaction to the potential offered by vinyl-clad metals is contradictory. The potential advantage is so broad that it's hard to believe. But, when full realization does begin to develop, enthusiasm tends to go too far!

Therefore, your vinyl-clad metals data file should be assembled with care. Know exactly what you are considering, when to use it, and how.

Clad-Rex is a vinyl-metal laminate. Obviously, it is a material that will give your product the almost unlimited color, style and texture of printed film plus the strength of steel or the weight advantage of aluminum. (Their alloys, including aluminized and galvanized, are also commonly used.)

However, not so obvious is the unusual opportunity Clad-Rex offers to simplify and reduce the cost of production procedures. These savings in time, labor, equipment, factory floor space, rejects, etc., are worthy of close examination.

Here's why . . .

Clad-Rex is pre-finished

Unlike *un*finished sheet metals, Clad-Rex is finished when you get it. Unlike other pre-finished metals, Clad-Rex offers unusual resistance to abrasion. Normal fabricating procedures and shop handling do not damage the vinyl surface of Clad-Rex. In most cases, existing tooling can be used without change—even for deep drawing.

Unfinished metal—complex methods

The inherent ability of Clad-Rex vinyl-metal laminates to simplify production procedures and sharply reduce manufacturing costs can best be described by a comparison.

Consider, for example, a cabinet for television—Using *un*finished sheet metal, the cabinet begins in forming and drawing. Next, cleaning to remove drawing compounds, etc. then, grinding and/or polishing. Now the various attachments and supports for the television and chassis are welded in position.

The next phase is preparation for finishing. This includes several steps of cleaning and surface preparation—often special treating, such as bonderising against corrosion.

Finally, finishing begins with prime coating. Often multiple finish coats. Then, baking. Through this sequence is inspection and re-inspection all along the way.

Now comes assembly, and more inspection. A slip of a screw driver here, or an abrasion in handling produces a reject. A reject means a complicated reverse process to disassemble, strip the paint, re-buffing and then back through the finishing line all over again.

Clad-Rex—simple, less cost

Now consider the same television cabinet. Only this time made of Clad-Rex vinyl-metal laminate—

Clad-Rex comes out of the forming dies, through inspection and directly to assembly. No buffing to remove die marks . . . no finishing of any type . . . usually no rejects during assembly either.

The time, labor, equipment, floor space, etc., required are much less. All represent a substantial savings when you use Clad-Rex vinyl-metal laminate *instead of unfinished sheet metal.* That's why, although Clad-Rex costs more going into your plant, your product made of Clad-Rex can cost less when you ship it.

A source of engineering service

Clad-Rex interest in helping you extends into your own plant. A Clad-Rex Fabricating Engineer is available to show your production people how easy it is to process Clad-Rex. Furthermore, Clad-Rex operates a fully staffed and equipped research laboratory. Its facilities are devoted to customer service as well as improving Clad-Rex products.

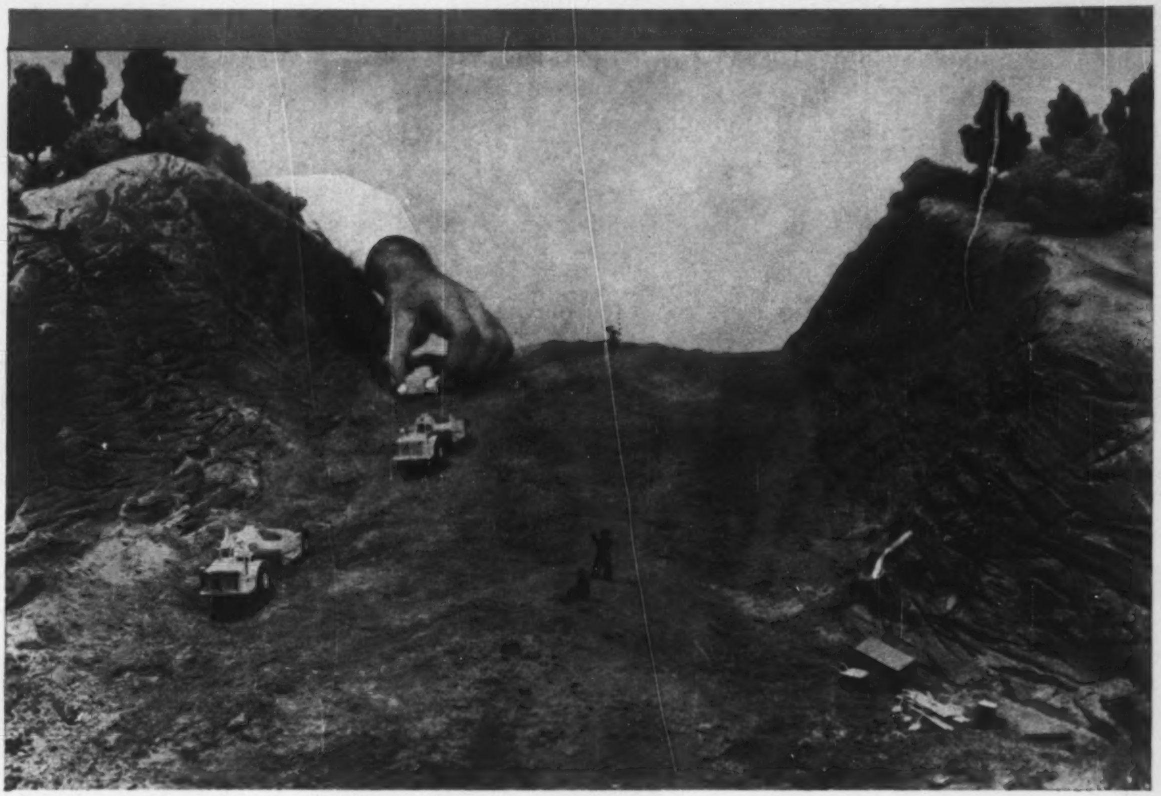
Write and describe your product. See how Clad-Rex can work its broad effect on your manufacturing methods and costs. No obligation, of course.

COMPARISON OF FABRICATING PROCEDURE

Unfinished Sheet Metal	Clad-Rex Vinyl-Metal Laminate
FORMING	FORMING
CLEANING	CLEANING
INSPECTION	INSPECTION
GRINDING, ETC.	
INSPECTION	
SUB-ASSEMBLY	SUB-ASSEMBLY
INSPECTION	INSPECTION
CLEANING	
BONDERIZING	
INSPECTION	
FINISHING (multiple coats as required)	
INSPECTION	
STRIPPING of rejects	
REFINISHING	
INSPECTION	
FINAL ASSEMBLY	FINAL ASSEMBLY
INSPECTION	INSPECTION
STRIPPING of rejects	
REFINISHING	
INSPECTION	
RE-ASSEMBLY	
INSPECTION	
SHIPPING	SHIPPING

VINYL-METAL LAMINATES BY **CLAD-REX** DIVISION OF SIMONIZ COMPANY
2109 Indiana Avenue • Chicago 16, Illinois
Telephone: VIctory 2-7272

For more information, turn to Reader Service card, circle No. 388



Custom made for rugged service

Big-job earth moving is a slamming, bruising, round-the-clock business that plays hob with construction machinery. Only the best custom-designed equipment can take the brutal punishment.

And only the finest, toughest seamless tubing can come up smiling in this rugged service. Custom quality Ostuco Tubing stands the gaff . . . fills the bill order after order.

If you're now compromising with stock tubing, consider all the advantages of custom quality Ostuco Tubing. Consistently you receive the exact tubing you want—the size, length, grade—with the strength and tolerances you need. For machined parts, you get our recommended rough size guaranteed to clean up.

With all these advantages, custom quality Ostuco Tubing is obtainable in small minimum quantities—as little as a few hundred feet. Contact your nearest Ohio Seamless representative, or the plant at Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.

A-1282A

Scale model illustrated built to 3.5 mm scale.

OSTUCO
STEEL TUBING

Complimentary Copy of new Bulletin CS60 "Ostuco Steel Tubing" sent on request.

OSTUCO
SHELBY, OHIO

OHIO SEAMLESS TUBE

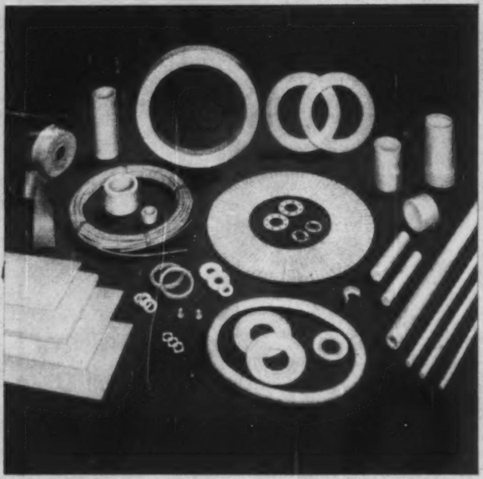
Division of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Miami, Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita

CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

For more information, turn to Reader Service card, circle No. 383



TEFLON (above), NYLON, C.T.F.E., DELRIN, other industrial plastics are available from Garlock for a wide range of electrical, mechanical and chemical applications.

WORLD'S LARGEST STOCK OF PLASTICS, such as this Nylon rod and tubing, is located in warehouses convenient to you . . . assures you prompt service any time, anywhere.

DIFFICULT MOLDED AND MACHINED PARTS, like these of Teflon and C.T.F.E., offer no problem to Garlock . . . intricate shapes, thin sections, close tolerances are routine.

PLASTICS

in Design Engineering

HOW TO SAVE TIME AND MONEY

Choose Garlock as *the* source for all your plastic needs. They've had years of experience in injection molding, compression molding, extruding, punching, machining, and grinding of stock shapes and intricate parts. "Know-how" like this enables Garlock to recommend and furnish plastic materials *exactly* as you need them . . . without delay and at the lowest possible cost.

Garlock offers a wide selection of shapes and parts—regardless of size, tolerance, or quantity—in these engineered materials:

Teflon† TFE—contains the finest combination of chemical, electrical, and mechanical properties . . . chemically inert, outstanding electrical qualities, low coefficient of friction . . . withstands temperatures as low as −395°F, as high as +500°F.

Nylon—guaranteed bubble-free . . . has high tensile and compressive strength, good resistance to heat and chemicals, solvents, oils and greases, retains toughness at temperatures ranging from −40°F to +350°F.

Polychlorotrifluoroethylene (C.T.F.E.)—colorless, non-flammable . . . offers excellent dielectric properties, high compressive strength, resistance to chemicals, low cold flow in temperatures from −400°F to +390°F.

Teflon FEP—combines the exceptional properties of Teflon with the advantage of being easily melt-processed . . . **Delrin†**—offers metal-like strength and rigidity over a wide temperature range . . . **Polyethylene**—light, flexible, excellent electrical properties . . . **Polypropylene**—lightest of all known materials.

Garlock will work directly to your specifications or, upon request, will gladly assist you in product design and development.

GARLOCK

For complete information contact one of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada, or write for Plastics Catalog AD-171, The Garlock Packing Company, Palmyra, N. Y.

Canadian Div.: The Garlock Packing Company of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

†DuPont Trademark

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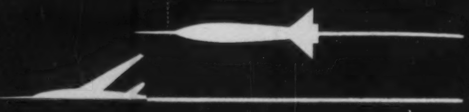
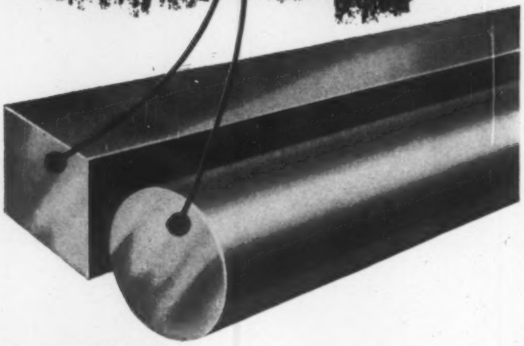


For critical design applications . . .

VAC-ARC* Steels



Latrobe's know-how guarantees reliability

Production know-how gained in making highest quality tool and die steels gives Latrobe an advantage in producing VAC-ARC (consumable vacuum melted) steels to meet critical design requirements. VAC-ARC Steels possess unusual cleanliness, improved ingot structure, and superior mechanical properties.

VAC-ARC
Grades Available . . .

APPLICATION	TYPE	GRADE NAME
High Temperature	A-286	Pandex
Bearings	M-50	MV-1
	52100	Regent
Aircraft & Missile	H-11	Dynaflex

Compare!

TYPICAL TRANSVERSE TENSILE PROPERTIES
(8" square billet of Dynaflex)

Property	Mid-Radius		Center	
	Air Melt	Vac-Arc	Air Melt	Vac-Arc
Tensile Strength (psi)	285,000	287,000	285,000	285,000
Yield Strength .2% (psi)	250,000	252,500	245,000	250,000
Elongation %	4	8	2.5	8
Reduction of Area %	10	25	3	24

Call your Latrobe representative . . . or write for literature.

LATROBE *Metalmasters*

LATROBE STEEL COMPANY
LATROBE, PENNSYLVANIA

BRANCH OFFICES and WAREHOUSES:
BOSTON • BUFFALO • CHICAGO • CLEVELAND • DAYTON • DETROIT
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*Latrobe's Trade Name for Vacuum Consumable Electrode Melting

For more information, turn to Reader Service card, circle No. 332

General Motors
announces
a new name
for its
Moraine Products
Division

DELCO MORAINE

BRAKE ASSEMBLIES • POWER BRAKES • BRAKE FLUIDS • BEARINGS • SINTERED METAL PARTS • FRICTION MATERIALS • DAYTON, OHIO

DEPENDABLY MADE

For more information, turn to Reader Service card, circle No. 386

call FANSTEEL for

TANTALUM
SHEET

get it
AS FAST...AS DEPENDABLE
as requisitioning from your own stock room

IMMEDIATE DELIVERY ON THESE THICKNESSES

.002	.007	.020
.003	.010	.025
.004	.013	.030
.005	.015	.040

Write for our latest price bulletin 2.602 giving complete prices for both stock items and special mill runs.

FANSTEEL
TANTALUM
SHEET
FROM STOCK

Planning to use tantalum in your product? Already using it? In either case, you can count on immediate delivery from stock of Fansteel tantalum sheet.

A little over a year ago, we introduced an exclusive Fansteel service of stocking the more commonly used sizes of tantalum sheet. The demand was immediate. Now we've expanded our stocking program to include 7 more popular sheet sizes. To you it means that you'll get the tantalum you need . . . exactly as ordered . . . delivered when you need it.

And this Fansteel service will save you time and money by giving you the flexibility of quick deliveries and lower inventory costs.

MOLYBDENUM USERS get the same benefits from the Fansteel Molybdenum Sheet stocking program.

FANSTEEL

HIGH TEMPERATURE METALS

K601

FANSTEEL METALLURGICAL CORPORATION North Chicago, Ill., U.S.A.

For more information, turn to Reader Service card. circle No. 396

ENGINEERING & DESIGN

...AT A GLANCE

Radiation does not impair the lubricating properties of molybdenum disulfide. Friction tests performed on irradiated and non-irradiated molybdenum disulfide specimens show that irradiated specimens have a coefficient of friction of 0.057, compared to 0.056 for non-irradiated specimens.

Source: E. E. Smith, Climax Molybdenum Co., 500 5th Ave., New York 36.

New data on dispersion-strengthened alloys show that particle spacing is an important factor in determining strength of an alloy. Until recently it was assumed that the closer the spacing the greater the strengthening. The new data show that although increased spacing means a decline in strength, this trend reverses itself when spacing is increased to a critical point. At this point strength increases again, reaches a peak with further spacing, and again declines.

Source: Ervin E. Underwood, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.

A 'synthetic sun' generating temperatures over 7000 F can be used to evaluate the heat resistance of metals, ceramics and other materials. Heat rays from high temperature carbon arcs are bounced off elliptical mirrors to a focal point in the center of a room. A "sun" about the size of a basketball forms at the point where the heat rays overlap.

Source: G. T. Wendelken, Waltham Precision Instruments Co., Waltham, Mass.

Some plastics and rubbers can cause metals to corrode in tropical and temperate environments, recent research indicates. Phenolic resins, chloroprene rubbers and sulfur-vulcanized SBR rubbers seem to be the most corrosive.

Source: Rpt. No. 6036, U. S. Naval Ordnance Laboratory, White Oak, Md.

Creep rupture and fatigue properties of metals at high temperatures are appreciably affected by the presence or absence of air. Creep specimens are stronger in air than in a vacuum at high temperatures and low stresses. The reverse is true at low temperatures and high stresses. Limited fatigue data show similar behavior. Two opposing phenomena—strengthening by oxidation and weakening by lowering of surface energy—are involved.

Source: M. R. Achter, U. S Naval Research Laboratory, Washington, D. C.

A rapid method for determining the service life of tinplate works by producing an electrical current between a pure tin electrode and a tinplate specimen that has been detinned to the iron-tin alloy layer. The detinned specimen and the electrode are submerged in grapefruit juice during the test. Service life is indicated by measurements of the current flowing between the tinplate specimen and the electrode after 20 hr. It formerly took two years to determine the service life of tinplate.

Source: G. G. Kamm, American Can Co., Barrington, Ill.

A method for cold extruding titanium metal consists of coating the metal with a fluoride-phosphate coating then lubricating with a graphite-molybdenum disulfide lubricant. Unalloyed titanium wire and tubing have been extruded successfully by the new technique.

Source: A. M. Sabroff, Battelle Memorial Inst., Light Metals Div., 505 King Ave., Columbus 1, Ohio.

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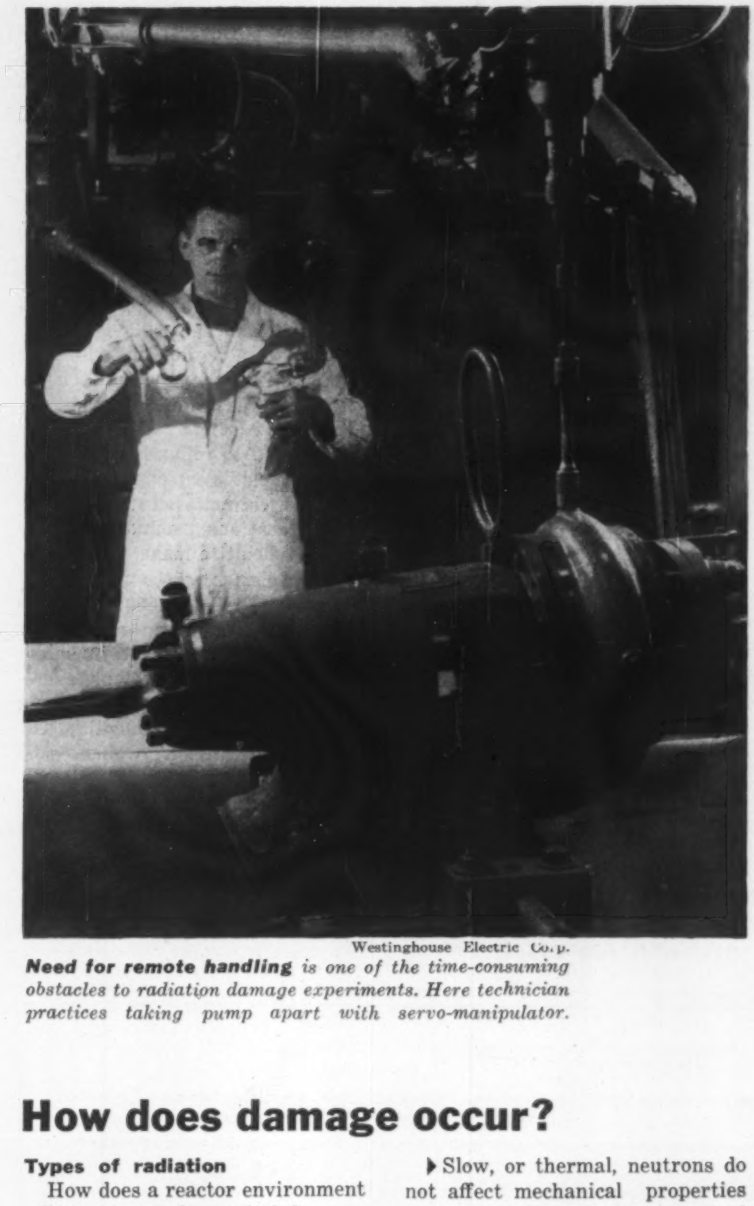

Westinghouse Electric Corp.

***Need for remote handling** is one of the time-consuming obstacles to radiation damage experiments. Here technician practices taking pump apart with servo-manipulator.*

A simple explanation of

Radiation Damage in Metals

- *How it occurs*
- *Its effects on properties*
- *What to do about it*

by Donald Peckner, *Associate Editor, Materials in Design Engineering.**

How does damage occur?

Types of radiation

How does a reactor environment affect structural materials?

▶ Gamma radiation has, at the most, an ionizing effect which does not affect metal properties.

▶ Electrons (or beta particles) do not have sufficient mass to cause any real effect, since they are incapable of transferring much kinetic energy to an atom they collide with, even when the energy of the electron exceeds one million electron volts (1 mev).

▶ Slow, or thermal, neutrons do not affect mechanical properties to any great extent. The principal effect of thermal neutrons is to produce transmutations, which can plague the reactor engineer. For example, the use of boron dispersions in metallic solids is not possible in control rods because the thermal neutrons react with the boron nucleii to produce lithium and helium. The helium is trapped in the solid, which ultimately causes swelling and bursting of the control rod. The nuclear reaction is shown in the second paragraph below. Thermal neutrons have an energy level of about 0.025 ev.

▶ Fast neutron bombardment is the one type of radiation that appears to have the greatest effect on the physical and mechanical properties of structural metals.

The basic effects of neutron bombardment on metallic materials are: 1) the production of interstitial atoms, 2) formation of vacancies in the metal lattice, 3) dislocations (with their consequent effect on metallurgical phenomena), and 4) the introduction of impurity atoms into the lattice by transmutation (such as in the reaction: ${}_5B^{10}+{}_0n^1\rightarrow{}_3Li^7+{}_2He^4$).

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*Written while the author was employed in the Materials Engineering Dept., Westinghouse Electric Corp.

Except for the formation of impurity atoms, radiation-induced damage shows considerable instability and therefore tends to rearrange and anneal itself out at all but very low temperatures.

What fast neutrons do

When a fast neutron strikes the metal lattice, the cumulative effect at the point of impact, on the atomic scale, is cataclysmic (see Fig 1). The struck (or knocked-on) atom is raised to a high energy level and ejected from its lattice site, while the neutron itself proceeds on, possibly to strike other atoms before its energy is dissipated. The fast neutron does not interact with *electrons* in its path and consequently produces no ionization effect.

The reaction between the high energy neutron and the lattice atom actually acounts for only a small part of the radiation effect. The knocked-on atom plows through the dense metallic medium, producing electronic excitation (or ionization) and further ejection of atoms from lattice positions. As the knocked-on atom loses energy because of glancing collisions with other atoms, it slows down. The *glancing collisions* decrease in frequency, and ionization thus declines. But *lattice ejections* begin to increase in number as the knocked-on atom slows down. The ejected atoms spray out through the lattice, and many will have sufficient energy to produce further displacements in a cascade type of process.

Two important concepts

The simple displacements caused by independent knock-ons do not present the full picture of radiation damage. The coordinated behaviour of the affected atoms must be considered. Two important concepts—the thermal spike and the displacement spike — have been proposed.

Thermal spike—Along the path of the knocked-on atom there will be many glancing collisions that set lattice atoms into oscillation without displacing them from their lattice position. These excited atoms will transfer energy to their neighbors, and a more or less violent agitation will affect all atoms in this vicinity for a short while.

In the thermal spike it is believed that a region consisting of anywhere from 3 to 1000 atoms will be raised above the melting point (but not melted) and then quickly cooled within 10^{-12} to 10^{-11} sec through heat conduction by the large unaffected mass of metal. Regions further away are briefly warmed to a lesser extent and then cooled again after the thermal pulse passes over them.

Any process whose rate is promoted by heating — diffusion, phase change, disordering, etc.— should be stimulated by the spike. The spikes should occur in clumps or clusters along the path of every energetic knock-on. There is still speculation concerning the actual mechanism of the thermal spike.

Another probable effect of the thermal spike is the production of dislocations. The sudden superheating of a region of 1000 atoms would strain the surrounding material to the point of producing dislocation rings. Although the rings tend to collapse, they probably are not completely erased. A reliable estimate of the number of dislocations produced appears to be difficult to make.

Displacement spike—In the displacement spike, 10,000 or more atoms are brought rather violently to the molten state with turbulent plastic flow and complete rearrangement, followed by rapid quenching and resolidification. The resolidified region would most probably be in registry with the mother lattice, since solidification proceeds from the outside in, but some areas might show disregistry and dislocation loops which formed should remain.

J. A. Brinkman proposed the displacement spike, as opposed to

What the Terms Mean

Barn. Neutron absorption cross section. (One barn $= 10^{-24}$ sq cm per nucleus.)

Deuteron. Particle containing one neutron and one proton. Designated as ${}_1H^2$.

Fast neutron. One with an energy level ranging upwards from 1000 electron volts. Average energy is assumed to be within the range 0.5-2 mev.

Fission particle. The product of a nuclear reaction. In the reaction: ${}_7N^{14} + {}_2He^4 \rightarrow {}_80^{17} + {}_1H^1$, the proton ${}_1H^1$ is the fission fragment.

Interstitial atom. One which comes to rest at other than a normal lattice site.

Knock-on atom. The atom which is struck by the incoming energetic particle.

Mev. One million electron volts. Equivalent to 1.6 x 10^{-6} erg.

Neutron. An uncharged particle having the same mass as a proton. Designated as ${}_0n^1$.

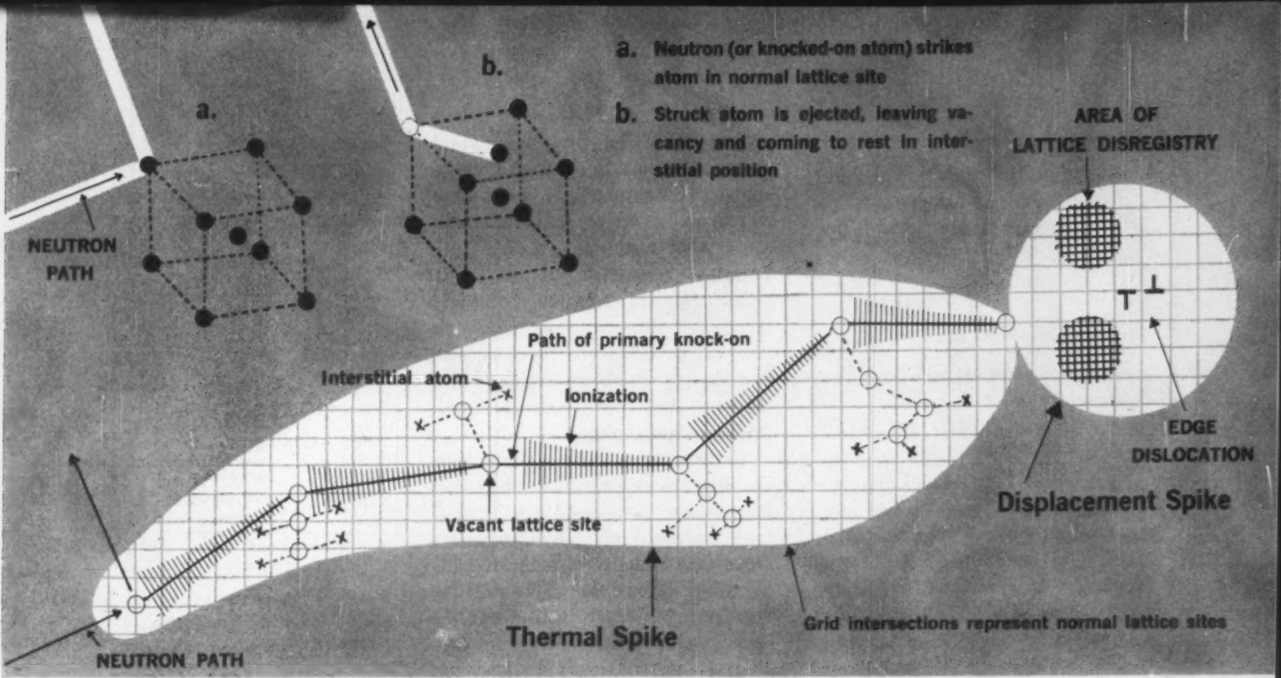
Neutron flux density. Unit is nv, where n is neutrons per cm^3, v is velocity in cm per sec, and nv is thus neutrons/sq cm/sec.

Proton. A charged particle about 1800 times heavier than an electron. Has a positive charge equal to the electron's negative charge. Designated as ${}_1H^1$.

(n,α) reaction. One in which a neutron interacts with a metal nucleus to form an alpha particle and another particle or chemical element. Example: ${}_5B^{10} + {}_0n^1 \rightarrow {}_3Li^7 + {}_2He^4$ (alpha particle).

Total flux. Unit is nvt, product of neutron flux density and time in sec. Expressed as neutrons per sq cm.

Vacancy. A space which is formed when an ion is removed from a lattice position.


a.
b.
a. Neutron (or knocked-on atom) strikes atom in normal lattice site
b. Struck atom is ejected, leaving vacancy and coming to rest in interstitial position
AREA OF LATTICE DISREGISTRY
NEUTRON PATH
Path of primary knock-on
Interstitial atom
Ionization
EDGE DISLOCATION
Displacement Spike
Vacant lattice site
Thermal Spike
Grid intersections represent normal lattice sites
NEUTRON PATH

1—*Schematic diagram shows effect of passage of an energetic knock-on atom through a metal.*

the thermal spike, on the basis that, in a material with very closely spaced atoms, when the energy of the primary knock-on fell below some transition energy, the particle would be brought to rest very quickly (within 100 Angstroms). This quick stopping would produce an intense shower of interrelated secondary displacements (rather than the independent secondaries of the thermal spike). The concept of the displacement spike is also unverified.

Lattice defects

That part of radiation damage theory dealing with the production of vacancies and displaced, or interstitial, atoms appears to be on a relatively firm foundation —at least as it relates to order of magnitude estimates of the various lattice defects. However these estimates are not the only figures needed. It is important to know the equilibrium number of these lattice defects as a function of the irradiation temperature or the annealing temperature after irradiation.

Temperature affects the mobilities of the vacancies and interstitials; if their mobilities are high, the probability is good that vacancies and interstitials will be lost through recombination, migration to grain boundaries, or other lattice defects. At present the effect of temperature in changing the number of vacancies and interstitials is known, semi-quantitatively at best, for only a few metals. There also appears to be some trouble in obtaining a satisfactory understanding of the role that lattice defects play in determining the mode of deformation and fracture of metal under stress.

Total Flux Not Key

Although changes in properties induced by irradiation will vary with exposure, data indicate that the total flux exposure has no equivalency. Thus, an exposure of 100 hr in a flux of 10^{14} nv (fast) does not produce the same results as exposure for 1000 hr in a flux of 10^{13} nv (fast) even though total flux is the same.

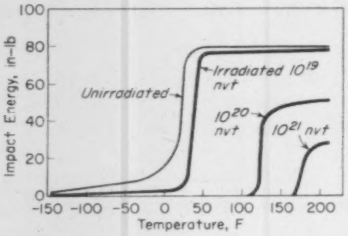
How radiation damage affects properties

The effect of radiation on metals is greatest in annealed materials and decreases in magnitude as lattice defects are introduced by cold work or heat treatment. Experimental data, to date, have shown that radiation-induced changes can be removed almost completely by "annealing out" the defects introduced after neutron bombardment.

Yield strength

Radiation increases yield strength most markedly in materials with the least amount of prior strain. An increase in yield strength of approximately 150% —equal to that obtained by rolling the material to a half-hard condition—was obtained in 1100 aluminum. Similarly, a 62% increase in yield strength—equivalent to giving annealed material a 5% reduction in thickness—was obtained in sponge zirconium. By way of contrast, 5154 aluminum, cold reduced 50%, showed an increase in yield strength of only 6.3% after neutron bombardment.

The effect of radiation on yield strength is understandable. The number of defects already present in cold worked or heat treated



2—*Effect of total flux exposure on the impact energy curve of ASTM A 212B carbon-silicon steel.* (Wilson and Berggren)

material is probably significantly high. The creation of additional vacancies, interstitials, or pinned dislocations in a metal containing a large number of defects should not add significantly to the yield strength. The accompanying table shows the magnitude of the change which occurs in several materials after irradiation.

Tensile strength

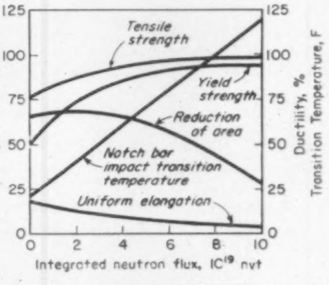
Effects are similar to yield strength observations, although not as pronounced. The accompanying table shows some of the changes that have been observed.

Fatigue strength

Experiments have been performed to determine the S-N curves for 304 stainless, crystal bar zirconium (Westinghouse Grade 1), and a zirconium-2.5% tin alloy. The curves did not differ significantly from those of the non-irradiated controls.

Creep strength

On the basis of available data, the creep strength of metals is not seriously reduced by neutron



3—*How properties of ASTM A 212B steel depend on integrated fast neutron flux.* (Wilson and Berggren)

EFFECT OF NEUTRON BOMBARDMENT ON STRENGTH OF VARIOUS METALS

Material ⬇	Irradiation		Post-Irradiation Treatment	Yield Strength		
	Exposure[a] (nvt)	Temp, F		Pre-Irrad, 1000 psi	Post-Irrad, 1000 psi	Change, %
Zirconium[b, f]						
Annealed	2.4×10^{20} (s)	125-140	None	34.5	56.1	+62.7
	2.4×10^{20} (s)	125-140	100 Hr at 572 F	34.5	47.4	—
Cold Reduced 20%	2.4×10^{20} (s)	125-140	None	71.3	84.7	+18.8
	2.4×10^{20} (s)	125-140	100 Hr at 572 F	71.3	71.6	—
Cold Reduced 50%	2.4×10^{20} (s)	125-140	None	83.7	94.5	+12.9
	2.4×10^{20} (s)	125-140	100 Hr at 572 F	83.7	76.8	—
1100 Aluminum[c, g]						
Annealed, Recrystallized	1×10^{20} (f)	150	None	6.8	17.1	+151
Half-Hard	1×10^{20} (f)	150	None	16.6	24.0	+44.5
5052 Aluminum						
Annealed, Recrystallized	1×10^{20} (f)	150	None	14.7	22.9	+55.8
Half-Hard	1×10^{20} (f)	150	None	29.5	36.4	+23.4
6061 Aluminum						
Annealed, Recrystallized	1×10^{20} (f)	150	None	9.5	25.6	+170
Solution Treated, Aged	1×10^{20} (f)	150	None	38.5	44.4	+15.3
5154 Aluminum[d] (cold reduced 50%)	1×10^{20} (f)	150	None	47.8	50.8	+ 6.3
ASTM A 302B Steel[e, h]	3.7×10^{18} (f)	465-535	None	65.0	72.1	+10.9
		675-725		64.2	67.5	+ 5.2
ASTM A 106 Steel (normalized from 1700 F)[e, i]	1×10^{19} (f)	140	None	50.4	71.6	+29.6
	2×10^{18} (f)	570	None	50.4	53.9	+ 7.0
ASTM A 212B Steel (normalized from 1900 F)[e, i]	1×10^{19} (f)	140	None	50.1	65.4	+30.5
	1×10^{20} (f)	200	None	50.1	93.8	+87.2
301 Stainless Steel[e, i]	3.9×10^{19} (f)	200	None	38.4	87.0	+126
	7.8×10^{19} (f)	200	None	38.4	87.0	+126

[a] s—slow neutron flux; f—fast neutron flux

Specimen data:

[b] Standard ASTM tensile, ¼-in. dia, 1-in. gage length.

[c] Sheet tensile, 0.032 in. × 0.250 in., ½-in. gage length.

[d] Same as c except 0.062 in. thick.

[e] Tensile specimen: 0.180-in. dia, 1-in. gage length.

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[f] Kemper, R. S. and Kelly, W. S., "Effect of Irradiation on the Mechanical Properties of Zirconium," Preprint 78, ASTM, '56.

[g] Steel, R. V. and Wallace, W. P., "The Effect of Neutron Flux on the Mechanical Properties of Aluminum Alloys," LRL 145, USAEC, TIS, Oak Ridge, Tenn.

bombardment. Most workers report little or no effect on creep rate as a result of exposure to a flux of 5 x 10^{13} nv (fast) max.

Transition temperature

Work on carbon steel (using subsize Izod impact test specimens) indicates that the ductile-to-brittle transition temperature is drastically raised as a function of total flux exposure (see Fig 2).

Fig 3 shows the general effect of irradiation on the mechanical properties of steel when the temperature of exposure is below 200 F. The same general effects have been noted in nonferrous materials.

Elastic properties

Several workers have irradiated clock mechanisms whose springs were made from Elinar (50% iron, 40% nickel, 10% chromium) and determined changes in Young's modulus by measuring in-pile changes in the timekeeping ability of the clocks. No changes in the modulus were noted. Post-irradiation tests on single crystals of aluminum and copper resulted in detectable, but insignificant, changes in Young's modulus, shear modulus and Poisson's ratio.

	Tensile Strength		
	Pre-Irrad, 1000 psi	Post-Irrad, 1000 psi	Change, %
	64.1	71.2	+11.1
	64.1	65.2	—
	78.0	88.5	+13.5
	78.0	77.9	—
	86.7	95.7	+10.4
	86.7	83.2	—
	13.6	26.0	+91.3
	17.3	26.0	+50.2
	29.2	37.4	+28.1
	36.0	44.7	+24.2
	18.1	37.3	+105
	45.0	50.6	+12.5
	54.7	57.8	+ 5.7
	91.5	95.3	+ 4.2
	89.8	92.6	+ 3.1
	85.0	89.5	+ 5.3
	85.0	86.4	+ 1.7
	75.0	80.8	+ 7.7
	75.0	97.1	+29.5
	98.7	113.2	+14.7
	—	—	—

[h] Baldwin, E. E., "Effects of Temperature and Radiation Upon the Tensile and Impact Properties of ASTM A 302B Manganese-Molybdenum Steel," KAPL 1416, pp 1-58, '55.

[i] Wilson, J. C. and Berggren, R. G., "Effects of Neutron Irradiation in Steel," *Proc ASTM*, Vol. 55, p 689, '55.

What to do about radiation damage

As the discussion and data indicate, the effects of radiation damage (increase in transition temperature, increase in mechanical properties, decrease in ductility, etc.) can be nearly eliminated by raising the temperature to which a component is exposed. The table shows that tensile specimens which received a post-irradiation heat treatment suffered a negligible change in properties compared with those which received no thermal treatment after exposure to a neutron atmosphere.

In general, irradiating specimens at or near 600 F will practically eliminate all radiation-induced defects, with the result that properties are restored almost to their pre-irradiation level. The decrease in radiation-induced changes is most easily explained by the elimination of defects. Vacancy-interstitial pairs recombine and dislocations migrate to grain boundaries or annihilate each other as the temperature is raised.

What does this mean in practice? It means, for example, that the designer of a reactor may well specify that after reactor shutdown, when the transition temperature of steel structural components may have increased dangerously, stress not be imposed on the reactor system until some elevated temperature is reached. The increase in temperature should reduce the transition temperature of the steel, and consequently decrease the possibility of brittle fracture.

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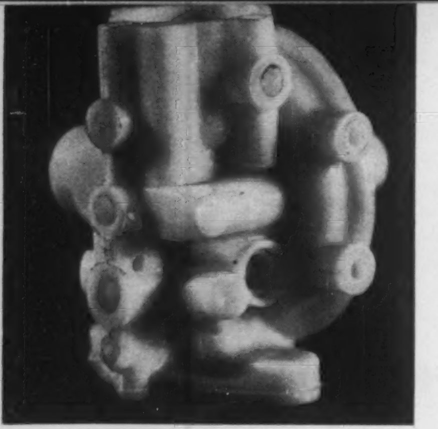


Meaningful specifications *for this complex nylon carburetor venturi insured economical moldings of good quality.*

How to Specify Molded Plastics Parts

This practical guide will help you get the materials, design and performance you want at the lowest possible cost.

by R. L. Miller, *E. L. du Pont de Nemours & Co., Inc.*

■ The purpose of a specification for a plastics part is to assure that the finished part will perform as intended. The scope of the specification depends on the performance required of the part. In general, as a specification becomes more complex the cost of the part increases. Consequently the best specification covers the critical needs of the application and omits nonessential requirements.

Specifications prepared by the end-user are directed at two suppliers: the resin supplier and the processor (molder, extruder, etc.). The specifications should require 1) the resin supplier to provide materials which meet minimum quality standards, and 2) the processor to shape the resin according to the design so as to meet the performance requirements of the part.

Thus, meaningful specifications for plastics parts must cover:

- **Base resin.** The resin specification should distinguish the material from any possible substitute and provide a check on resin uniformity.
- **Part design.** The design specification should insure that the geometry of the part is such that the part will function properly for the intended use when correctly fabricated.
- **Performance.** The performance specification should provide a means for detecting property changes caused by processing conditions.

Usually the base resin and performance specifications are given in the written part of the specification. Specifications which pertain to the whole part, such as overall tolerances and finish, are also given in the written specification; design details are given on the working drawing. A sample specification and a checklist for drawing specifications are shown on the opposite page.

This article discusses molded thermoplastics specifically. The same approach is generally applicable to specifying molded thermosetting materials, with, of course, some differences in particulars.

Resin specification

The section of the specification dealing with base resin should be divided into two major parts: identification and quality.

Identification—If the material selected by the engineer is produced by one manufacturer only, the specification should include the resin's tradename, generic name, type code numbers, and the name of the manufacturer. Wherever design requirements can be met by a specific grade, type or composition supplied by several manufacturers, the specification should be written to permit qualification by more than one base material supplier.

Identification tests should be specified to assure that the material received is the material specified. Such standard ASTM tests as melting point, specific gravity and solubility should be used, e.g., polyethylene can be broadly identified by specific gravity and melt index.

Quality—Quality tests, such as ASTM viscosity and tensile tests, should be specified to check resin uniformity. Empirical tests for color, contamination, or irregularity in particle size may also be included. For example, tensile elongation and low temperature brittleness tests can be used to detect degraded polyethylene.

In many cases, processors do not carry out these standard tests, which can be costly. The determination and maintenance of the quality of the resin is the responsibility of the resin supplier and, for the most part, resin suppliers hold close to their published range of physical properties. Consequently, the processor often relies on the manufacturer's demonstrated ability to consistently deliver quality material. Should significant changes in resin occur (i.e., in color, contamination or processability), the processor consults the resin manufacturer.

Design specifications

An important key to both economical production and satisfactory performance of the part is the specifications shown on the working drawings (general specifications pertinent to the entire part should be shown on the written specification as well as in the title block of the drawing). Be sure to include where applicable on the drawing critical detailed specifications, such as color, specific finishes, tolerances on critical dimensions, and parting lines and gates. These critical specifications are costly to meet; the processor must know about them to accurately estimate the cost of producing the part. By including such specifications, you eliminate the possibility of getting an unrealistic bid from a processor.

Sample Specification

Part name: Squeeze Bottle
Code: SBP

A. Resin
- *A.1.—Polyethylene*[a]
  - *A.1.a. Specific Gravity: 0.918.0.922*
  - *A.1.b. Melt Index: 1.5-2.5*
  - *A.1.c. Natural color*
- *A.2.—25% rework permissible*

B. Design
- *2.a.—Overall tolerance: ±0.005 in. per in. except where noted on drawing (Other overall design specifications from accompanying check list should be listed as applicable to specific part.)*

C. Performance
- *C.1—Weight loss of packaged ingredients: 0.1 gm per day at 72 F circ air*
- *C.2—Stress crack resistance of bottles packaged with ingredients: no leakage in 100 hr at 130 F.*

---

[a] Where only one resin meets the resin specification, the trade name and specific grade designation should be used.

Checklist: Design Specifications for Drawings

1. Resin
- *a. Basic description of resin: specification or code (trade-name, generic name, manufacturer)*
- *b. Color, color code*
- *c. Percent rework permissible*

2. Dimensional Tolerances (describe environmental conditions for measurements
- *a. Overall tolerance: ±in. per in.*
- *b. Specific tolerance: indicate as ±in. per in.*
- *c. Indicate surfaces requiring post-machining*

3. Surface Finish
- *a. Gloss, polish; indicate where desired*
- *b. Voids; indicate where not permissible, maximum size permissible*
- *c. Blisters, splay; indicate where not permissible*
- *d. Tool marks; indicate where not permissible*
- *e. Weld lines; indicate where not permissible*
- *f. Flow marks; indicate where not permissible*
- *g. Parting lines; indicate desired location*
- *h. Gate; indicate desired location, finishing*

4. Color, Contamination, Warpage
- *a. Provide samples showing permissible limits*

5. Post-Treatment
- *a. Moisture content: procedure and condition*
- *b. Annealing: procedure and condition*

Following are several of the more important design specifications which you should include on the drawing.

Resin—Already detailed on the written specification, the tradename, or code number, and color should also appear on the drawing.

In many cases, permitting the processor to use a certain percentage of rework material (e.g., sprues and runners, which are reprocessed, then blended with virgin resin) can reduce part cost without impairing quality. The percentage allowed depends on the factors controlling final quality of the part. Use of excessive rework can result in dimensional variation, color change and loss of physical properties. State maximum percentage allowable clearly on the drawing.

In general, molders should be allowed to rework all sprues, runners, and parts rejected for reasons other than resin discoloration or contamination. Rework percentages as high as 30% on quality parts are not uncommon; 20% is about average.

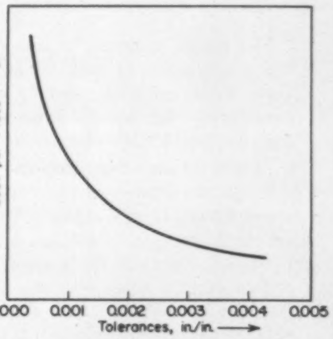
Scrap resin (i.e., resin which is contaminated or nonuniform in viscosity or color) should seldom be used. Even when the end-user permits its use, the molder may suffer from nonuniform processing characteristics.

Dimensional tolerances — The accompanying graph shows why tolerances should be only as close as required for proper performance of the part. For tolerances below ±0.002 in. per in., unit cost rises rapidly.

The working drawing must also show the conditions under which the dimensions shown must be true, i.e., the drawing should state that dimensions shown are to be correct after molding, after annealing, after moisture conditioning, etc.

Other important recommendations:

1. Give overall tolerances in the title block in in. per in., not in fixed values, e.g., "All decimal dimensions ±0.00X in. per in. (*not* ±0.00X in.), unless otherwise specified."



Cost per piece *goes up rapidly when tolerances must be closer than ±0.002 in. per in.*

2. Label only those tight tolerances required for specific dimensions; let overall tolerances control less important dimensions.

3. Allow generous molding tolerances in areas to be post-machined.

Production variables such as

number and size of cavities in a mold also affect tolerances. Where compromises in tolerances may be acceptable from the performance standpoint, discussing such tolerances with the molder may result in economies. For example, use of a multi-cavity mold is usually the most economical production method. But as the number of cavities per mold increases so must the tolerances on critical dimensions. An increase of 1-5% *per cavity* is about average. For example, dimensions of a part produced in a single cavity mold may be held to ±0.002 in. per in.; when the number of cavities is increased to 20, the closest tolerances obtainable may be ±0.004 in. per in. (an increase of 5% per cavity, or a total increase of 100%).

EFFECT OF PROCESSING ON PHYSICAL PROPERTIES
(Type III Polyethylene[a])

Molding Method ➔	Compression Molded	Injection Molded
Stiffness, psi	89,000	63,000
Yld Str, psi	3,450	2,930
Elongation, %	1,050	640

[a] Comparative data only; tests run on similar specimens at same strain rate.

Surface finish—Indicate clearly on the drawing the type and degree of surface finish required on specific surfaces. If a surface does not require a highly polished appearance, specify degree of finish permissible. Also specify clearly where surface imperfections, such as tool marks, sinks, blisters and flow lines, are not permissible. On hidden surfaces where such imperfections are unimportant, do not mention them unless they would create harmful stress concentrations.

Voids—Areas which must be void-free should be clearly indicated on the drawing. Unnecessarily specifying areas to be void-free, however, can increase the cost of a part. The presence of voids within a part does not in itself mean the part is defective. Most thermoplastics tend to form voids in thick sections due to shrinkage on cooling. The only measure of the importance of a void in a part is whether the function of the part is affected to a *critical* degree. A void causing a *critical* loss of strength or a void impinging on an area to be machined cannot be tolerated.

The nylon carburetor venturi cluster shown in the photo on p 94 is an example of proper specification of void-free areas. Only those areas where orifices have to be drilled after molding are specified to be void-free. Other areas do not require this specification.

Actually, there is evidence that the formation of voids within a thick section is a form of partial stress relief which may result in improved dimensional stability. Also, it does not seem logical that voids create harmful stress concentrations reducing impact strength, since 1) voids are usu-

Two Problems in Specifying Plastics Parts

The major problems in specifying plastics are 1) lack of materials standardization, and 2) unfamiliarity of many engineers and designers with plastics.

1. Lack of standardization

SAE 430 stainless steel is a standard grade of material. When specified to any stainless steel producer, the material is supplied within certain compositional limits; its properties fall within clearly defined ranges of values.

Unlike such older engineering materials, plastics have not reached the point where numerous manufacturers produce essentially identical materials. Although the plastics from a single producer are uniform, there is not the interchangeability of source which is available to purchasers of specification metal alloys.

Consequently, even in a single type of plastic, e.g., polystyrene or polyethylene, wide ranges of properties are available to the end-user. Progress in classifying plastics types into groups having similar physical properties is being made by the various societies. But for the most part, engineers must still rely on property data published by individual materials producers.

Although useful, product data sheets alone are not an adequate basis for specifying successful performance of the fabricated part. Specifications on the finished parts are also necessary.

2. Unfamiliarity with plastics

Although there are many designers and engineers experienced in plastics, the rapid increase in the use of plastics as engineering materials has brought many engineers face-to-face with these materials for the first time. Such an encounter may understandably lead to difficulties because of unfamiliarity with plastics engineering and processing information.

The suggested steps that follow should help the non-plastics engineers develop a satisfactory new plastic part.

1. Have a designer familiar with plastics review the design and develop tentative specifications. Competent outside assistance is available from independent consultants, processors, and materials suppliers.
2. Contact an experienced processor to discuss a) part design as related to economical processing, and b) tentative specifications.
3. Complete working drawings and produce a prototype for actual or simulated service testing. Review and modify design in the light of service test results.
4. Get bids from established processors. (At this point, specifications should be complete, including expected performance of part. When precision molding is required, bids should include sample cavity for confirming final dimensions.)
5. Select processor and work with him closely on production mold. Screen initial production thoroughly. Set up quality control based on specifications.

ally spherical with smooth interior surfaces, and 2) voids are usually centrally located deep within the section where bending stresses are at their lowest.

Parting line—The mold parting line must often be placed at a special location because of appearance, location of flash, or structural design considerations. In such cases, parting line location should be specified on the drawings, usually after consultation with the molder.

Flash—Indicate clearly areas where flash is undesirable (the same reasons apply as in parting line location). Also provide an overall value on both the written specification and the drawing indicating the maximum dimension of flash. Remember that a no-flash specification is expensive. It requires either special tooling or a finishing operation.

Gating—In general, indicate location of gates, at least indicate areas where gates should *not* be located. If possible, always locate gates in nonstressed areas, and where finishing is not required. Again, consult your molder.

Color—Color matching is difficult; the closer the color match, the more costly the part can be. The end-user should submit samples showing the variations permissible.

For the most part, compliance with the other specifications, such as percent of rework, and dimensions, will assure good control of color providing there is no unreasonable color variation in the virgin resin supplied by the resin manufacturer. Method of coloring the resin should be left to the processor.

Warpage — Allowable dimensional warpage should be specified. Where very little or no warpage is permissible, cooling parts may be clamped in a fixture.

Post treatments—Describe all post treatments in detail on the drawing, i.e., annealing, moisture conditioning, etc.

Performance specifications

End-use or performance tests are the final assurance that the part will perform satisfactorily. Such specifications should be based on the least number of tests that will assure proper field performance. In general, performance specifications should be set up on a statistical control sampling basis and should include visual inspection in addition to one or more physical tests representative of the end use.

Drop test *is an effective, inexpensive, simulated service test. Aerosol bottle is filled and dropped 6 ft.*

Visual inspection — Visual inspection is one of the best ways to control product quality. Normally, physical tests are run in conjunction with visual inspection. In some cases, however, visual defects can be correlated directly with product performance and physical testing may be eliminated.

For example, breakage of a plastic hand mirror frame always occurred at the weld line opposite the gate. Experience showed that the frame could be expected to break if the weld line were visible under controlled inspection; this criterion was written into the performance specification.

Another example is an acrylic hairbrush block. Blocks found by visual inspection to exhibit surface crazing or internal voids are rejected prior to the bristle stapling operation, because these defects were found to cause cracking or low bristle pull-out strength.

Standard tests—Standard tests to measure physical properties of the fabricated part should be used provided that 1) the test is representative of the end use, and 2) the test is performed on the finished part, not on a specimen cut from the part.

For example, a plastics screw or bolt can be evaluated in standard testing machines by determining tensile and shear strengths. On the other hand, a tensile or compressive test would not be representative of the end use of a plastics tumbler. Also, properties of specimens cut from the tumbler are likely to be different from published values because of the effect of processing conditions. The accompanying table shows the substantial effect processing may have on tensile properties of a plastic.

Simulated service tests—The most informative test that can be applied to the part is the actual end use. Practically all types of consumer and industrial products undergo at some time an end use or "service" test. This type of test, however, is used primarily in proving out the design of the part and is usually too expensive and time consuming to be used as an acceptance test for a commercial part.

A more practical test is the simulated service test. The simulated test should represent the actual use as nearly as possible, yet be simple, informative, reproducible, inexpensive, and preferably nondestructive. An accompanying photo shows a typical simulated service test on a plastics aerosol bottle. The filled bottle must not break after dropping 6 ft onto a steel plate.

Typical of other simulated service tests:

1. A nylon drawer roller. Static load equivalent to maximum service load is applied to roller for 8 hr at 90 F. Permanent deformation is determined by moving drawer on roller; roller must roll, not slide.
2. Nylon worm gear. Gear must not break when tooth is engaged and 1-lb weight is dropped 2 ft onto end of shaft.

Gas Plating

How the process works
Current and potential uses
Properties of coatings
Limitations of the process

by **Carroll F. Powell,** *Battelle Memorial Institute*

The term gas plating is synonymous with vapor plating or vapor deposition. In these processes a solid or liquid coating is chemically produced from a gas or vapor in contact with a substrate. The reaction is generally induced by making the substrate hotter (in a few cases, colder) than the gas, thus disturbing the chemical equilibrium in the gas so that a reaction occurs and a solid or liquid coating is deposited on the substrate.

The terms vapor plating and vapor deposition are sometimes used in reference to the evaporation of a metal in a high vacuum. However, this evaporative process is better known as "evaporative coating" or "vacuum metallizing." It does not provide the high plating rates and heavy thicknesses obtainable with the gas plating process.

Some previous articles on gas (or vapor) plating have tended to give engineers the impression that the process was ready for immediate, wide-scale application. The facts are that outside of chromizing and siliconizing the process is still in the development stage, and that most of the successful applications have been rather specialized and on a small scale. However, the process still offers great potential, and continuing research is underway to overcome its limitations and develop new applications.

It is difficult at the present stage of development to give specific cost figures on parts coated by gas plating. Some metals can be deposited very rapidly by gas plating (the process has been used experimentally to continuously coat wire), their plating compounds are readily available and relatively inexpensive, and their as-deposited cost may prove to be lower than electroplated coatings. On the other hand, some metals can be applied only by gas plating and comparisons of their as-deposited cost with other deposition processes is meaningless.

Five main advantages

Under ideal conditions gas plating offers certain important advantages over other conventional plating processes. The process can:

1. Deposit coatings that cannot be electroplated or applied in a nonporous condition by other methods. Some of the unusual coatings that can be applied by gas plating are titanium, zirconium, columbium, tantalum, molybdenum, tungsten, and refractory compounds such as the transition metal carbides, nitrides, borides and silicides.

2. Plate unusual base materials such as plastics and other nonmetallics. Gas plating can be used on almost any material which is not melted or decomposed at the processing temperature. Some of the metals that have been successfully coated include iron, steel, copper, molybdenum, tungsten, chromium, titanium, zirconium, uranium and aluminum. Coatings have also been used on such nonmetallics as glass, quartz, porcelain, graphite, alumina, glass fibers, silicone rubber, paper and plastics. Materials such as silicone rubber, paper and plastics which are easily affected by heat are usually plated from easily decomposable vapors of metal carbonyls, hydrides and organometallic compounds.

3. Plate irregular surfaces. Since the coatings are applied from a gaseous state they usually show less tendency than electroplates to build up on high spots or form dendrites, and less tendency to leave thinly coated edges than sprayed or enamelled coatings. In addition some coatings have good penetration in hidden areas.

4. Permit high production rates. In many cases, thin coatings can be applied in just a few seconds or minutes. In general, deposition rate is about 1 to 2 mils per hr.

5. Produce ultra high purity metals and compounds. Gas plating deposits are often purer than deposits obtainable by any other method and are useful in alloy development and in electronic applications.

Current and future uses

At present the most important commercial uses of gas plating are:

— Application of high-chromium alloy coatings to iron and steel parts. The process used in applying these coatings is commonly known as pack chromizing and is essentially a displacement-diffusion deposition technique. It is usually used to improve the abrasion resistance of carbon steel and to protect surfaces from corrosion by strong oxidizing acids, alkalis, salt solutions and food products. It also protects surfaces from gaseous combustion products at temperatures up to 2200 F.

— Application of molybdenum disilicide coatings to molybdenum for protection against air oxidation at high temperatures.

— Preparation of ultra high purity titanium, zirconium, chromium, thorium and silicon by iodide vapor decomposition.

— Preparation of junction transistors by controlled diffusion of boron from boron halide on the surfaces of silicon and germanium wafers.

At present, gas plating processes (except for pack chromizing) are applicable to approximately isodiametric objects no larger than 8 to 10 in., and with no deep undercuts or blind recesses. Objects such as nozzles, thermometer wells, rings, bushings, crucibles, cups and dies have been successfully plated. Wire up to 0.1 in. in dia has been plated continuously. In addition, rods and tubing several feet long and from 0.15 to 2 or 3 in. in dia can be plated externally and internally (in the case of tubing).

The pack chromizing displacement diffusion process uniformly plates comparatively large pieces having complex shapes and inaccessible areas. Rods and sheet up to 2 or 3 ft long have been coated, and indications are that the process can be used on even larger pieces.

In addition to the above commercial applications, the following coatings have been prepared in developmental work:

— Tantalum coatings on iron and steel for corrosion resistance.

— Vanadized, tungstenized and molybdenized iron for wear resistance.

— Tungsten coatings on copper x-ray and cyclotron targets.

— Conductive metal coatings on glass, porcelain, alundum, porous bodies, rubber and plastics.

— Refractory metal coatings on copper wire.

— Oxidation resistant carbide coatings on graphite tubes, nozzles and vanes.

— Metallic coatings of all types on metal and nonmetallic powders.

— Decorative coatings on glass and glass fibers.

— High purity boron, rhenium, vanadium, germanium and aluminum.

The three application methods

Any material which meets the following requirements can be applied by gas plating: The material or its components must form a compound that can be vaporized at a relatively low temperature without appreciable decomposition. In addition, the volatile compound must be sufficiently unstable to be capable of decomposition or chemical reduction at a temperature somewhat higher than its vaporization temperature. Finally, the material to be deposited must not have an appreciable vapor pressure at the decomposition temperature. Here are the basic types of chemical reactions that meet the following requirements:

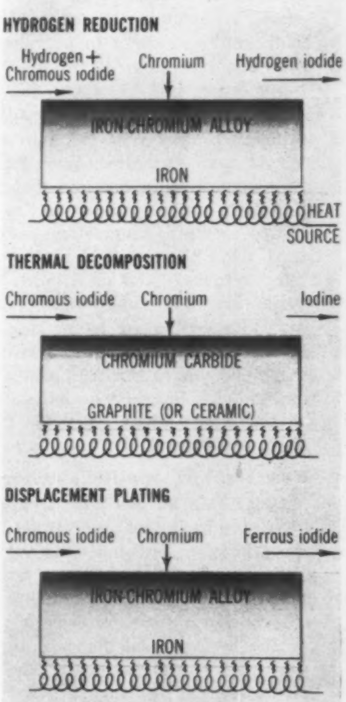
1. Hydrogen reduction plating

Hydrogen reduction of metal halide vapors is performed by saturating hydrogen with 1 to 10% by volume of the plating vapor and passing the mixture over the heated object to be coated. Since the plating vapor may, in a few instances, be reducible with hydrogen at the vaporization temperature, an inert carrier gas such as argon is used to transport the vapor to the plating chamber where it is mixed with hydrogen.

Many materials can be vapor deposited by hydrogen reduction of their halide (fluoride, chloride, bromide or iodide) vapors. These materials are: boron, silicon, titanium, zirconium, vanadium, columbium, tantalum, chromium, molybdenum, tungsten, iron, cobalt, nickel, germanium, tin, arsenic, antimony and bismuth. Depending on the halide used, these materials are deposited at temperatures ranging from 550 to 2600 F.

2. Thermal decomposition plating

Gas plating by thermal decomposition can be performed with halides, hydrides, carbonyls, organometallics or other volatile compounds. In addition to hafnium, uranium and rhenium, most of the metals listed in the previous paragraph can be deposited by thermal decomposition of their halide vapors.



Furthermore, thermal decomposition of metal hydrides can be used to deposit boron, silicon, germanium, arsenic, antimony and bismuth. Iron, cobalt, nickel, chromium, molybdenum and tungsten can also be deposited from their respective carbonyls, and copper and the platinum group metals can be plated from their carbonyl chloride compounds. Copper, iron, nickel, cobalt, and some of the platinum group metals can be plated by thermal decomposition of organometallic compounds such as the acetylacetonates and the biscyclopentadienyl derivatives.

A further demonstration of the potential versatility of gas plating is that more than one plating compound can be used in the plating atmosphere. Thus, it is possible to deposit alloys and compounds such as the refractory carbides, silicides, borides and some oxides, as well as sulfides, selenides, tellurides, arsenides, etc.

The operating temperature required in thermal decomposition plating varies over a wide range, depending on the materials used. Hydrides, carbonyls and organometallic compounds are decomposed at 300 to 1150 F, metal iodides at 1650 to 2550 F, and metal bromides and chlorides at 2200 to 3650 F.

3. Displacement plating

In displacement gas plating, part of the base material displaces a constituent of the vapor which in turn alloys or combines with the remaining base material. For example, an iron base will displace chromium from chromous chloride vapor. The resulting chromium combines with the iron base to form a high chromium stainless alloy.

The displacement process is conducted at high enough temperatures to permit fairly rapid interdiffusion of the plating metal, thus keeping enough base metal at the surface to sustain the reaction. It has been successfully used on iron and steel objects to apply coatings of chromium, aluminum, silicon, boron, titanium, vanadium, columbium, antimony, cerium, manganese, zinc, tin, molybdenum and tungsten alloys. It has also been used to apply chromium, silicon and boron coatings on molybdenum parts, and to apply titanium, zirconium, columbium and tantalum coatings on graphite parts.

The temperatures required with displacement plating depend largely on the composition of the base material. Coatings on iron and steel alloys are usually produced at 1300 to 2200 F. Refractory metals such as molybdenum are plated at temperatures of 1830 to 3300 F, and displacement carbide coatings are produced on graphite at 2550 to 4550 F.

Further Details on the Process

Vacuum may be required

Wherever possible gas plating is conducted at atmospheric pressure. However, in some systems (such as hydrogen reduction of molybdenum or tungsten halides, or thermal decomposition of the metal hydrides and carbonyls) plating must be conducted at reduced pressures because of the instability of the plating compounds. In such cases, a vacuum of 0.001 to 0.02 atm is required to prevent premature reaction of the plating mixture and resultant formation of powdery, nonadherent deposits.

Low pressures are also used in thermal decomposition plating from metal iodides to increase iodide decomposition and thus lower the required plating temperatures. And low pressures are sometimes used in displacement plating to increase the rate of diffusion of the plating metal and to remove plating by-products (e.g., lower halides of the base metal) as fast as they are formed.

How heat is applied

Objects to be gas plated can be heated by induction or resistance heating, internal radiant heaters ("hot fingers"), or by placing the part and coating chamber in a furnace. Selection of the best method depends on the nature and shape of the parts. Except for displacement plating, heating in an external furnace is generally the least desirable method since the bulk of the plating action occurs on the hot walls of the plating chamber instead of on the object to be coated. This results in very low plating efficiency and nonuniform plating of the object.

Production rates vary

The deposition rates in most gas plating processes can range from as low as 0.1 mil to as high as 20 mils per hr. However, the average rate obtained is 1 to 2 mils per hr.

Small objects plated with only a few tenths of a mil of metal by the carbonyl decomposition process can be continuously coated in only a few seconds or minutes per piece. Wire has been plated with 0.5 to 1-mil coatings at speeds of 120 ft per hr. Considerably higher rates have been obtained when plating thinner coatings on glass fibers. Molybdenum parts have been siliconized in the comparatively short time of 1 hr and less.

Pack chromizing generally requires a 3 to 6-hr treatment, plus additional time for loading, unloading and cleaning the parts. An additional 8 hr is required for heating and cooling the parts container. However, little supervision is required and overall cost per piece is low since hundreds or thousands of pieces can be treated in one operation.

Efficiency: 5 to 80%

Deposition efficiency usually ranges from 5 to 80%. This wide spread in efficiency is accounted for by variations in the heating method used, composition of the plating compound, and rate of gas flow through the plating chamber. In many cases efficiency can be improved by recovering and recycling unused plating compound.

Coating properties

Structure

The coatings applied by gas plating are more or less crystalline. Crystallites deposited at low temperatures are so small that the plate is virtually amorphous. In contrast, crystals deposited at high temperatures can range up to ¼ in. or more in diameter, depending on coating thickness. In general, size of the crystals tends to increase with plate thickness. For deposits less than 1 mil thick, smoothness usually approximates the finish of the base material.

Thickness

Depending on the application, the thickness of coatings produced by gas plating can range from a few millionths of an inch to ¼ in. or more. Coatings intended for corrosion or oxidation protection generally range from 5 to 10 mils thick. Techniques are now being developed to produce pore-free coatings in thicknesses of 1 to 2 mils. Coatings intended to provide only hardness and resistance to scoring and abrasion are usually not made over 1 mil thick in order to obtain some flexibility.

Adhesion

The adhesion or bond of a plated layer depends on the combination of plate and base material used, and on the temperature of application.

Low temperature deposits resemble electroplates and are mechanically bonded. Careful cleaning and degassing of surfaces are necessary to obtain strongly adherent deposits in low temperature plating. Adhesion can be further improved by etching or grit blasting before plating.

High temperature deposits may develop a diffusion layer at the bond if the coating material and substrate can alloy or react with each other. This diffusion layer usually improves adhesion and reduces the importance of initial surface preparation.

In some cases at high temperatures the coating and substrate may interact to form brittle, intermetallic or other compounds that make the bonding layer susceptible to easy fracture by mechanical or thermal stresses. This condition may occur, for example, with aluminum coatings on iron, and with tantalum and columbium coatings on iron and steel (in the latter case a brittle carbide or high carbon interlayer is formed). In such cases adhesion can be improved by applying (by gas plating or other techniques) a thin, intermediate coating of another material such as nickel before applying the main coating. Displacement-type coatings are always bonded by a diffusion layer and, because of the properties within this layer, generally have the best adhesion and lowest porosity of gas plated coatings.

Limitations of gas plating

1. Plating compounds tend to be unstable. In general, the compounds used in gas plating are relatively unstable and are easily decomposed by air and moisture. Thus, the compounds are more costly and difficult to store and handle than the compounds used in other plating techniques. In addition, some of the metal carbonyls, hydrides and organometallic compounds are highly toxic, a hazard which is intensified by their volatility. Furthermore, some of the hydrides and metal alkyls inflame spontaneously when exposed to air.

To develop the best coating properties, many plating compounds (particularly the moisture sensitive metal halides) must be purified and used without contamination from the atmosphere. However, deliberate contamination can sometimes be put to good use; adding nitrogen or moisture to the atmosphere can be used to produce harder deposits (e.g., titanium or tantalum) or to minimize unwanted codeposition of carbon (e.g., with molybdenum from the carbonyl).

2. Plates may be nonuniform. Thickness variations of 10 to 25% are common in gas plating. Nonuniform plating may occur in all processes, except the displacement process, if the gas flow pattern around the object is not controlled. Also, since nonuniform heating can cause nonuniform plating, the shape and mass of the object have to be considered in selecting the best heating method to obtain even heat distribution. In extreme cases these difficulties can be overcome by applying multiple coatings or by changing the direction of gas flow for each application.

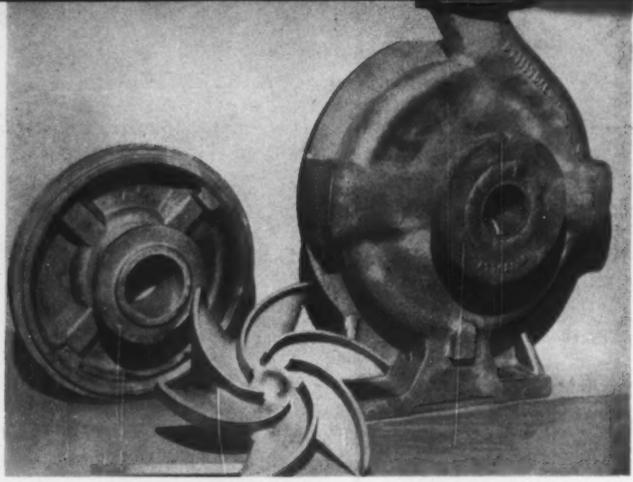
3. High temperatures can change substrate properties. The high temperatures used in gas plating can cause unwanted changes in the properties of the object being coated. Loss of temper, grain growth, dimensional changes, and alloy constituents precipitating or going into solution are some of the changes that can occur. However, in many cases changes can be prevented by careful attention to gas plating procedures.

4. Undesirable side reactions are possible. Undesirable side reactions in gas plating must be watched for and avoided. A particularly troublesome reaction in plating from metal halide vapors is the interaction of the base material and the halide vapor to form lower-valent halides, either of the base material or of the coating vapor. If the substrate temperature is too low or the plating vapor too rich, these lower-valent halides will condense at the substrate surface, producing a plate underlaid or contaminated with halide salts. Such contaminated deposits are always poorly adherent, porous, and sensitive to moisture. Incomplete reduction or decomposition of the plating vapor can produce the same result. Contamination of this type is less likely to occur when plating inert base materials such as graphite, glass and some ceramics.

Some metals such as tantalum, columbium and titanium have a strong affinity for hydrogen. These metals must be vacuum annealed or at least cooled in an inert gas after having been plated in a hydrogen atmosphere to avoid excessive hydrogen absorption.

If the substrate temperature is too high, carburization of substrate metals having a strong affinity for carbon may occur when plating with metal carbonyls. In some cases the metal of the deposit itself may be partially carburized, as when depositing molybdenum, chromium and tungsten from their carbonyl vapors.

1—*Cast zirconium pump impeller after one year in a complex corrosive solution. Previous materials lasted only 3-6 months.*



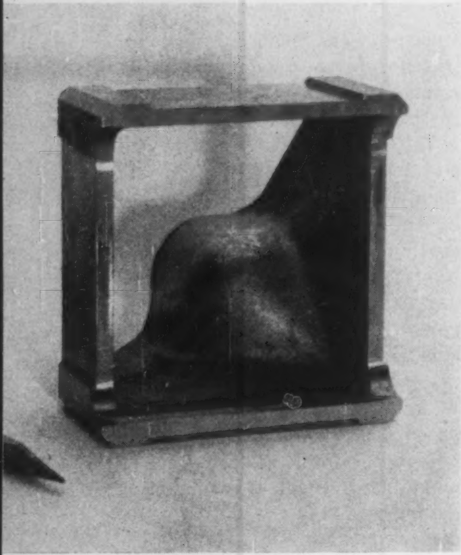
2—*Cast titanium centrifugal pump for use in hot chloride solution.*

Why to Use

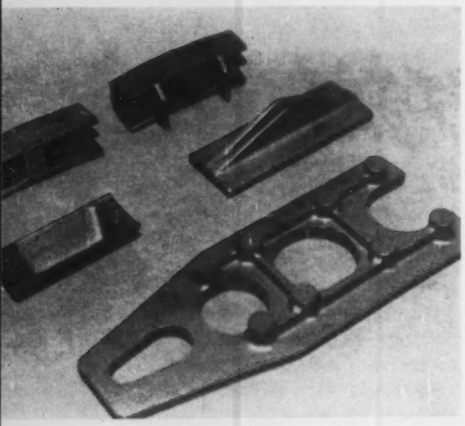
Titanium and Zirconium Castings

These reactive metals can now be cast into complex shapes, providing a minimum loss of expensive material. Expected users: the chemical, nuclear and aircraft industries.

by W. A. Aschoff,* *Manager, Development,*
Oregon Metallurgical Corp.
*Now Chemical Engineer, Wah Chang Corp, Albany, Ore.



3—*Cast Zircaloy-2 fuel element jacket extension bracket.*



4—*Cast titanium alloy structural components for a ramjet engine.*

High corrosion resistance

The bar chart compares the relative cost of titanium and zirconium castings with that of type 316 stainless steel and a high nickel-chromium alloy. The basis is dollars per year of service life. Three actual applications of titanium and zirconium castings bring this chart to life:

▶ Fig 1 shows a cast zirconium pump impeller after one year's service in a complex corrosive solution of dilute hydrochloric acid, zirconyl chloride, thiocyanic acid, 500-1000 ppm iron, and an abrasive polymer. There has been

TYPICAL MECHANICAL PROPERTIES OF CAST TITANIUM AND ZIRCONIUM

Material ⬇	Yield Strength (0.2% offset), psi	Ultimate Strength, psi	Elongation (in 2 in.), %	Reduction of Area, %	Hardness, BHN
Zirconium	40,000	65,000	20	—	160
Zircaloy-2	60,000	75,000	21[a]	32	170
Titanium	55,000	65,000	15	25	180
MST 6 Al-4 V, Rem Cru C-120AV	120,000	130,000	7	14	320

[a] Elongation, % in ¾ in.

virtually no attack. Under the same conditions glass-lined and high silicon components lasted only 3-6 months.

▶ Titanium pumps (Fig 2) operating in hot nitric acid, hot sodium hypochlorite, and various hot solutions containing chlorine and chloride salts, have outlasted stainless steel components by factors of 10-20 to 1.

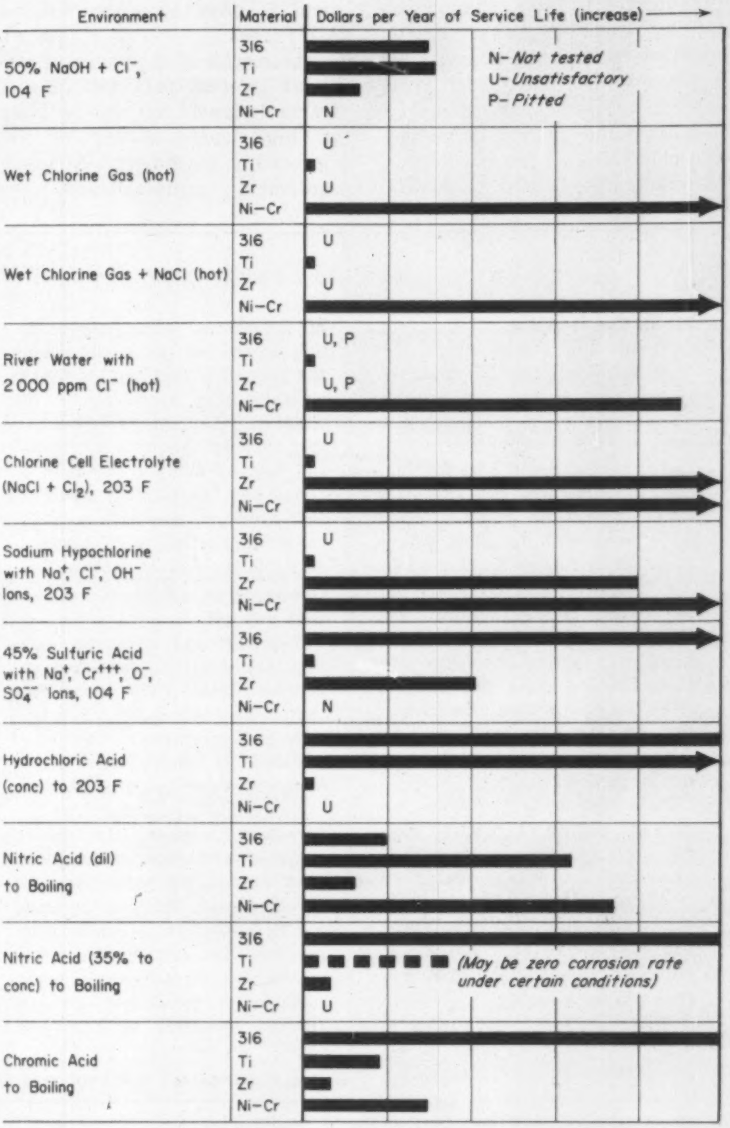
▶ Titanium shaft sleeves for pumps handling black liquor in a Kraft paper mill have required no attention after 13 months' service. The type 316 stainless components formerly used had a life expectancy of 3-6 months. Interestingly enough, the stainless components cost only 10% less than the titanium parts.

In considering titanium and zirconium castings for units handling highly corrosive chemicals, the extended service life of these metals is extremely attractive. Other factors to consider are the decrease in downtime, loss of chemicals, and cost of repairs, and the increase in such intangibles as health and safety (which may suffer in any failure of chemical plant equipment).

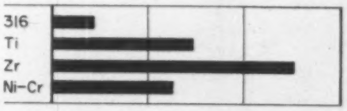
High nuclear efficiency

The availability of zirconium castings will probably have a significant effect on future reactor designs. In those cases where the designer has to choose between the higher neutron efficiency possible with zirconium, and the lower price of stainless steel components, a delicate economic balance frequently exists. A component designed with zirconium rather than stainless steel can use a lower enrichment level and, therefore, cheaper nuclear fuels.

With complex shapes such as the fuel element jacket extension bracket shown in Fig 3, metal recovery in casting is approximately 90%, as compared with 30% for either machining or forging. Cast parts exhibit satisfactory corrosion resistance, and their mechanical properties (see table) are as good as—or better than—specifications requirements for wrought products made with the same alloy.



Relative cost *of titanium and zirconium cast components compared with 316 stainless and high nickel-chromium alloy castings.*



Relative cost *of finished parts.*

High strength–weight ratio

Although the aircraft and missile industries have provided the greatest impetus for the development of high strength, low density titanium alloys, little use is being made of titanium alloy castings. Current commercial alloys, such as MST6Al-4V or Rem-Cru C-120AV, exhibit strength-density ratios greater than 850,000, and alloys now being developed show promise of developing strength-density ratios exceeding 1,100,000 while maintaining good ductility. Design parameters such as dimensional accuracy, feeding distances, x-ray inspection standards, strength, ductility, and fatigue properties are now being developed under a titanium alloy casting development program sponsored by the Air Force.

The results of the program will be of interest not only to airframe designers but also builders of high speed rotary or reciprocating machinery. Airborne equipment manufacturers, especially, will be able to make good use of the weight saving possibilities inherent in titanium castings. The ramjet engine components pictured in Fig 4 gave perfect service in a 50-hr static test—far longer than the expected engine life in actual service.

Let the Foundryman Help in Design

What the founder can tell the engineer

It is difficult for the foundryman to provide superior products at minimum prices when he must work with a design initially conceived for fabrication by forging, machining, or welding. The least expensive way to specify castings is to work with founders before a design is finally decided upon. The engineer and designer can be advised on 1) the draft required to facilitate pattern removal, 2) gradual section size transition to avoid the thermal centers which promote the formation of shrinkage voids, and 3) the most efficient method for coring a casting.

Mold materials suitable for vacuum casting of reactive metals, along with their advantages and disadvantages, are described in the table below. The methods of casting generally are: static and centrifugal for shape molds; centrifugal for tubular castings.

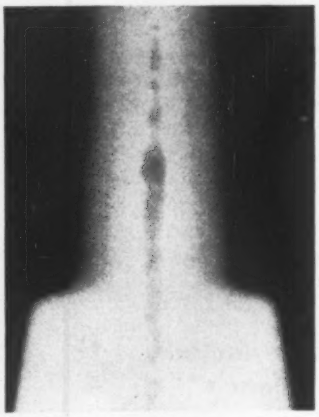
Don't over-specify

Since titanium is not subject to a spongy type of shrinkage porosity, leakage is not considered a problem. All shrinkage porosity encountered to date has been of the smooth wall, spherical void type, usually located at the centerline of the part, as shown in the accompanying radiograph of a valve. For this part, a specification based on a hydrostatic test would have more meaning to the customer than an x-ray test and would give the producer more latitude in planning for economical production.

In working with the foundryman to determine the most practical casting technique, the designer can decrease costs considerably by not over-specifying design requirements. Specifying an as-cast dimensional tolerance of ±0.005 in. when ±0.030 in. will do the job can easily double the cost of a casting. In certain aircraft alloy specifications for titanium, the cost of inspection and chemical analysis can equal the cost of making the casting. Using such an aircraft specification for a corrosion-resistant valve application adds unnecessarily to the cost of procurement.

Cooperative effort will pay off

Titanium and zirconium castings are relatively new and expensive items. (The small bar chart on p 103 shows their relative cost compared to two other metals.) If their useful properties are exploited through careful choice of application and cooperation between the design engineer and foundryman, they offer outstanding possibilities for reducing costs. Whether the parts are to be used to 1) extend service life in corrosive environments, 2) replace more costly methods of production or less efficient materials in a nuclear reactor, or 3) reduce the weight of an aircraft component by 1 lb (which may easily reduce the total weight of the plane by 9 lb), the planning and effort involved in obtaining optimum utilization of these materials will yield a high rate of return to the user.



Radiograph *shows centerline shrinkage in a titanium casting.*

MOLD MATERIALS SUITABLE FOR VACUUM CASTING OF REACTIVE METALS

Mold Material	Advantages	Disadvantages
Metal (permanent)	Close dimensional reproducibility to ±0.005 in. Long mold life. Little chance of metal contamination	Costly, limited shape application. Severely chills casting
Machined Graphite (semi-permanent)	Close dimensional reproducibility to ±0.010 in. Cheaper to produce than metal molds	Limited life, except in simple shapes with adequate draft. Chills casting
Powdered Graphite (rammed)	Uses conventional foundry patterns and forming equipment. Less chill than machined graphite with consequent improved feeding distance and surface finish	Requires high temperature firing prior to use. Dimensional accuracy generally ±0.030 in.[a]
Graphite Powder (shell)	Very cheap to produce in large quantities. Least chill effect of four types of molds	Requires high temperature firing. More expensive patterns. Limited shape applications

[a] Dimensional variation depends on size and shape of part to some extent. For rammed and shell molds, an added 0.005 in. is required over 3 in. and across parting lines.

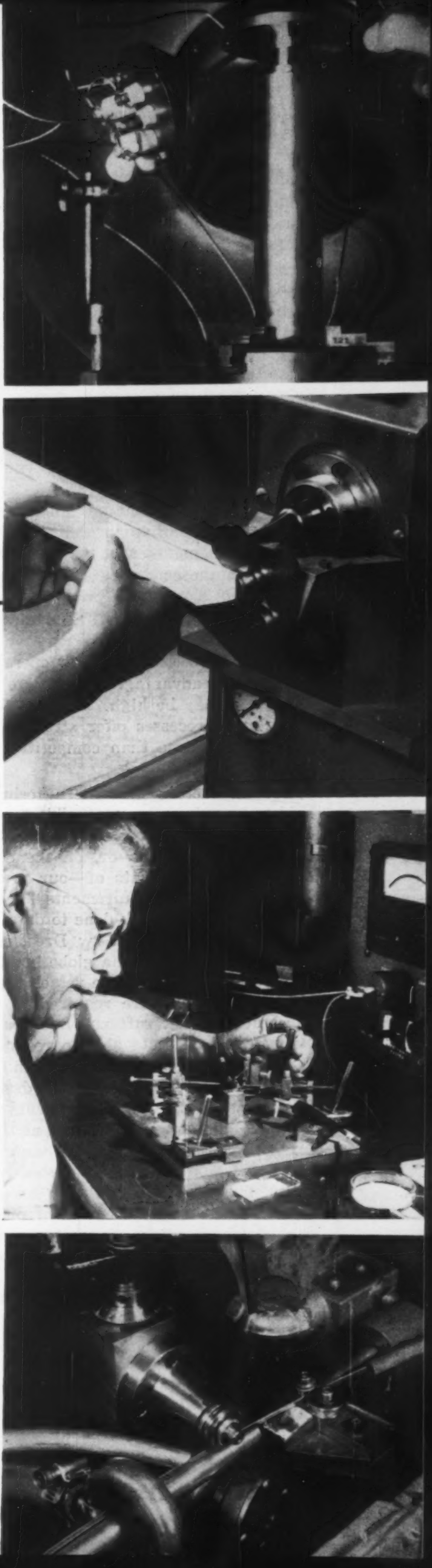
Capacitor Discharge
Diffusion
Electron Beam
Electroslag
Foil Seam
Forge
Friction
High Frequency Resistance
Magnetic Force
Percussion
Thermal Compression
Thermobaric
Ultrasonic

The New Welding Processes

by Jack C. Merriam, *Associate Editor, Materials in Design Engineering.*

The "new" welding processes range from the truly new to redevelopment of almost forgotten techniques. Many are still in the experimental stage; a few are becoming widely used in production. None has reached its full potential. This report tells what each process can do today.

M/DE Manual No. 166 · January, 1960



PHOTOS top to bottom: Electron beam (High Vacuum Equipment Corp.); ultrasonic (Aluminum Co. of America); thermal compression (Bell Telephone Laboratories, Inc.); high frequency resistance (New Rochelle Tool Co.).

Introduction

Many of the "new" welding processes are based upon re-examination and extended development of processes or applied principles which have been with us for many years. Others are truly new—that is, they are based upon tried and proved principles newly applied to welding, or at least now applied with practicability.

Although each of these processes could be traced back to a classification on the AWS master welding chart, there is nothing to be gained by such classification. Nor is there any point in comparing most of the new processes with each other. Each has been, or is being, developed for specific application in terms of materials, design or end-service requirements.

Most of the advantages and limitations of each process are peculiar to the application. The only general statements that might refer to the entire group are these:

1. Often a process provides the only feasible method of doing a job. Equipment and operating costs are usually high.
2. Some processes offer low operating costs as one of the major advantages. Here, too, the initial equipment cost may be high.
3. Some processes offer stronger welds with less heat-affected zone than competitive methods.

Why new processes?

Several factors in modern technology might be said to be primarily responsible for new or renewed interest in these processes. But all can be traced to the requirements of—or, on the other side of the coin, the developments of—our present atomic and space age. AEC requirements have been behind a large part of the work done to date. An outstanding example is the 180,000-kw Dresden Power station, for which the 109 ft-dia globe housing the uranium core reactor, the pressure vessel, the condensers and the steam pipes were required to be of all-welded construction. Aircraft and missiles require smooth, strong welded joints able to resist mechanical and thermal stresses. Both nuclear and space age technology have fostered materials developments which have resulted in new requirements for welding aluminum and magnesium, as well as the need for welding such metals as beryllium, titanium and zirconium.

At the same time that these requirements are being pushed on to welding processes, increased knowledge and equipment is becoming available in such fields as ultrasonic and nuclear energy, high frequency electrical power, vacuum processes, and metals purification.

Thus these two factors—requirements and developments—work together to accomplish continuing gains in welding technology.

How far have they advanced?

None of the processes to be described here has reached its full potential. It is doubtful that some of them ever will. Welding equipment suppliers and many large companies which depend on welding to fabricate their products have investigated these processes, but only a few are being widely used in production. For these few—such as ultrasonic, electron beam and high frequency resistance—the limits on sizes and thicknesses are determined only by the equipment available, not by the process. Larger and more powerful equipment can be, and will be, built when it is asked for (and paid for). Thus no one can predict, with any certainty, the full potential of these new processes.

Certain obvious problems exist for all these processes, as they will for any project still largely in the experimental or developmental stage. To pinpoint two:

1. Cost is often a major stumbling block; someone must pay for prototypes of equipment that may be complex and limited in application.
2. Tooling is a large problem area, both in design and materials. Holding fixtures for odd-shaped and sized parts; devices to transmit or dampen large quantities of various types of dynamic energy; materials to stand up under high voltages, temperatures or flashes; and equipment to hold, control and observe extremely tiny parts—these are some of the tooling problems requiring experience and ingenuity.

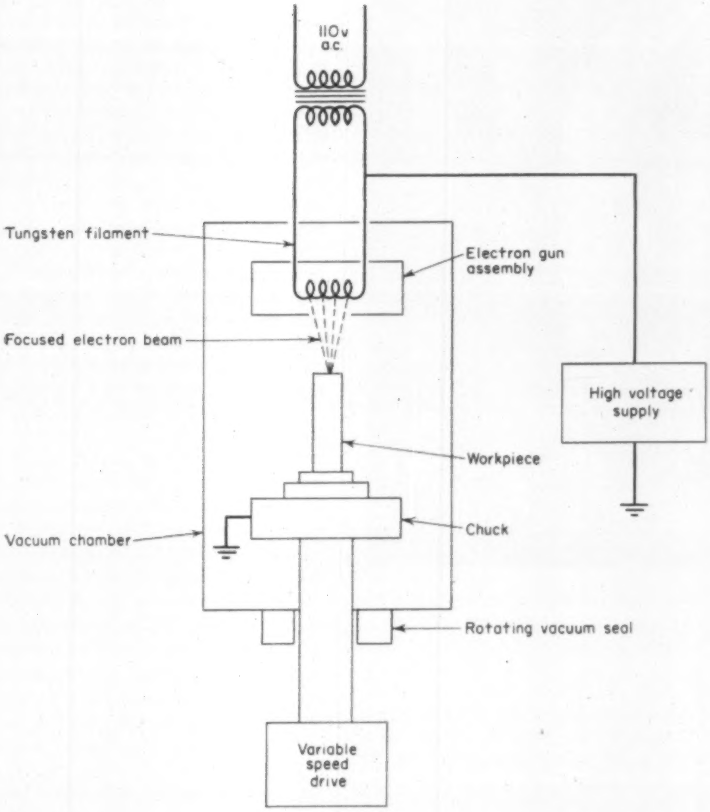
Are other processes to come?

First, let it be made clear that there have been, and will continue to be, developments in the standard welding processes which are not considered to be within the scope of this manual. To mention a few such developments: dip transfer carbon dioxide welding, filler metal fluxes, arc spot welding, automatic feedback control of welding. Nor have the standard processes been extended to their limits in terms of materials, designs and applications. These standard processes, and further development of them, will continue to be the foundation of the welding world.

As for "new" processes, there will certainly be more. In any welding operation, the problem is simply one of achieving intimate contact which will promote interaction between atoms of the surfaces to be joined.

Traditional methods accomplish this goal by heat fusion obtained through methods based on three physical phenomena: gas combustion (oxyacetylene welding), electric current jumped between electrode and surface (arc welding), and electric current passed between two surfaces (resistance welding).

Many of the newer processes merely use variations of, or other sources of energy for, these physical phenomena. Others achieve the necessary contact by different methods of obtaining heat or pressure, or by new and careful means of controlling the heat and pressure. In some processes, particularly the solid-state joining techniques, there is considerable overlapping of basic principles or methods.



Electron beam welding

Electron beam welding was developed to obtain ultra high purity welds of reactive and refractory metals, as well as thin sections of nickel and stainless steel, in the fields of rocketry and atomic energy.

This process is a method of heating metals in a vacuum and joining them by fusion. The principle involved in accomplishing the heating —directing a concentrated beam of electrons—is not new. It has been used, with different effects, in such electronic devices as the cathode ray tube and the electron microscope. But there the object was to produce light and to minimize the heat effect.

The first electron beam welders were built and used in France and West Germany before the first laboratory welder was set up in this country in 1958. Since then American manufacturers have entered the market. The American equipment differs principally in the voltages employed—5 to 50,000 v rather than 50,000 to 150,000 v—although one American manufacturer is now constructing a higher voltage machine.

The theory

The kinetic energy of a high velocity beam of electrons can be converted into thermal energy when the electrons strike the metal to be welded. (Some of the energy will be converted into radiation which may be an accompanying hazard.) A high vacuum is the only efficient environment for maintaining the focused stream of electrons and preventing arcing between the high voltage elements. The slightest pressure of air, 10μ or more, will diffuse the electron beam too much. At the high vacuum required (less than 1μ), there is no chance for entrainment of either active or inert gases in the weld zone. Furthermore, any pressure rises above the critical level will break down the beam; thus oxidation or contamination of the work is virtually impossible.

The welding process

After the welding chamber has been evacuated by a mechanical vacuum pump and a diffusion pump, a tungsten filament is heated to a temperature above 4000 F and thermionic emission of electrons takes place. A high voltage between the cathode and pieces to be welded (or, more recently, an accelerating anode) imparts velocity. It is the value of this voltage, which may range from 2000 to 150,000 v, that distinguishes the two basic types of welders.

As the electrons are accelerated to the weld area, they are focused into a beam by a simple electrostatic focusing system. Spot diameters for welding generally range from 1/32 to 1/8 in.

Some equipment provides an electromagnetic focusing system which allows an increase in the distance between the welding point and the gun, as well as further focusing of the beam to a spot as small as 0.010 in. dia. This system also permits the insertion of a shield to prevent gases and metallic vapors from reaching the high voltage regions in sufficient concentration to cause arcing.

Whatever the particular design, the thermal energy is highly concentrated at the metal surface and is sufficient to overcome the capacity of the adjacent body to absorb it through conduction.

How welding occurs

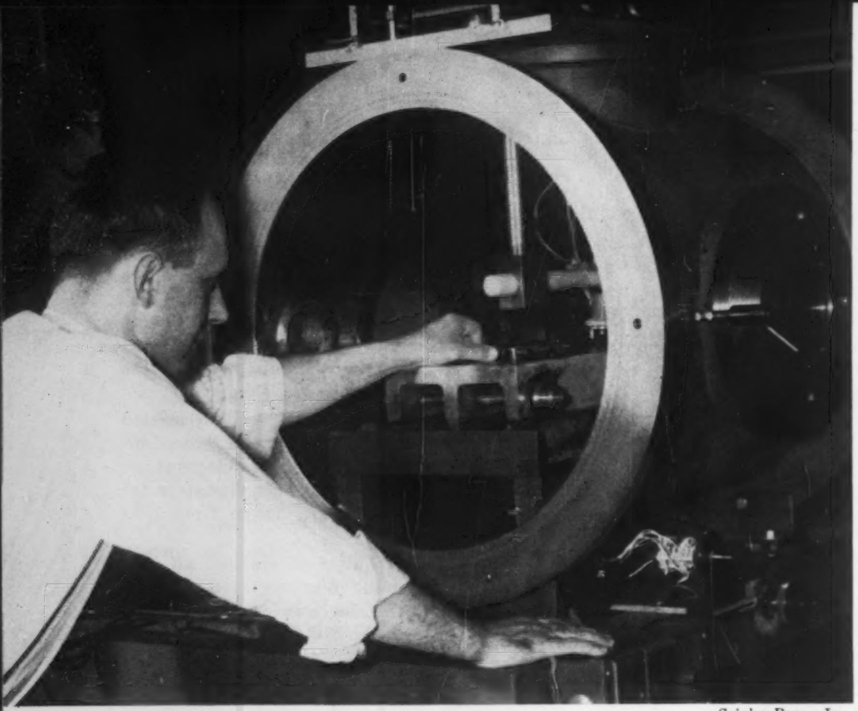
Both melting and vaporization occur within a localized area. It is believed that the heat input at the weld joint is concentrated below the work surface, inside the metal. The electrons do not pass entirely through the crevice at the joint because of the pool of molten metal which bridges the gap. It is the high concentration of thermal energy, and not the mechanical force of the accelerated electrons, that is responsible for the depth of the welds.

Advantages

The extended fabrication of such materials as molybdenum, titanium and zirconium, demanded by the expanding fields of rocketry and atomic energy, introduced problems which the inert-gas shielded arc welding processes tried to cope with—sometimes satisfactorily, but sometimes revealing shortcomings which opened the way to electron beam welding.

Some of the advantages of electron beam welding are the result of the environment—a high vacuum—and some are a direct result of the process itself.

1. *Ultra-high purity.* Welds of



Sciaky Bros., Inc.

Electron beam welding *is carried out in a high vacuum chamber.*

high melting, on highly reactive, materials can be made free of voids or porosity, as well as contaminants. Impurities are evacuated from the weld area as the beam is formed. Even nonmetallic inclusions are removed from the weld zone. In units in which the work serves as the anode, oxides, nitrides and carbides that are not destroyed by heating in a vacuum are ionized to positive ions by electron bombardment, then lifted out of the melt and attracted to the grid of the electron gun.

2. Small heat-affected zone. The heat energy is centered within a very small surface area with close dimensional and penetrational control. This provides a small width-depth ratio, from 1:3 to 1:1, providing fast and efficient heating. It also results in less distortion and permits welding of heat-sensitive assemblies.

3. Close control. The accelerating voltage, the beam current and—in electromagnetically focused units—the spot size, can all be independently varied so that total power concentration can be closely controlled. This permits: welding of materials with different melting points, welding of foil, and single pass welding of parts with varying section thickness. Unlike arc welding, close control here makes possible a precision weld at an acute-angle intersection.

4. Fast welds. For example, a 3-in. dia, 1/16-in. cap can be welded to a 1/16-in. zirconium alloy cylinder in an average time of 12 sec; the same weld in stainless steel can be made in about 10 sec. Maximum welding speeds depend upon the equipment design. One welder has 0.5 ips as a longitudinal maximum and 5 rpm max for circular welds. However, most have a useful range of 5-20 ips and 20 rpm max. On the other hand, loading and set-up require more time than the actual welding, and pumping the vacuum may take about 5 min. Work positioning fixtures can be used to rotate the work or move it laterally.

5. Low direct cost. While the initial investment is high, the only direct operating costs are labor, electricity and cooling water. The materials cost and handling expenses of using shielding gases such as helium and argon are eliminated.

6. Good joint efficiency. The joint efficiency is comparable to or better than that obtained by fusion welding in an inert gas atmosphere.

High voltage vs low

Contemporary domestic equipment has been developed primarily for operation in the 5 to 25 kv, 0.05 to 0.75-amp range at a maximum electron beam power of about 7.5 kw. The Zeiss (West German) high voltage equipment operates at 50 to 150 kv at less than 0.015 amp with a maximum beam power of 1 or 2 kw.

Voltage is important from the standpoint of penetration. Penetration is a function of the material being welded (melting point and thermal conductivity) and the total power and concentration of the beam. For the same power input, the higher the voltage the more concentrated the power and the deeper the penetration. There are some who feel that ultra-narrow, deep welds obtained by high voltages are necessary in sections of zirconium for nuclear applications. Others say that this is theoretical, not practical, because the sections to be welded are generally so thin that whether the depth-width ratio is 3:1 or 1:1 is relatively unimportant in the majority of applications.

The high voltage Zeiss machine has been used at the Bettis Atomic Power Div. of Westinghouse, primarily in the welding of Zircaloy-2 components for atomic reactors. Although mechanical and chemical properties of the welds were satisfactory, there were problems reported. Difficulty in arriving at and maintaining machine control settings led to excessive variability in weld penetration from one weld to the next. The machine, of course, was a laboratory model. Another problem is foreseen in production welding due to the heat buildup within the work during multiple pass welding on a large assembly. (In tungsten arc welding, the latent heat of fusion is transferred from the work to the surrounding inert gas atmosphere and then to the chamber walls where it is dissipated.)

Disadvantages

1. Radiation — At voltages over 20,000, the equipment must be well shielded to prevent x-ray radiation of personnel. Extremely thick sections, some of them protected by lead shields, and leaded glass in all the ports, must be used.

2. Type of work—The distance from the last focusing lens to the work may be as little as ½ to 2 in., particularly for the high voltage type, or the low voltage type when the work is the anode. (Other types allow an increase of this distance to 3 to 6 in.)

The weld area must be fairly flat. For example, it would be impossible to weld a corrugated section unless a work fixture could be designed to keep the weld area in a horizontal plane. Protuberances, particularly if they are sharp, may cause high voltage discharge. In addition, any spatter in the weld area may create shorts and operating difficulties.

3. Cost and complexity—At high voltages, the electric circuit must be quite elaborate in order to prevent overloading and malfunction. The cost of the European high voltage machines is five or more times that of the low voltage welders; cost of the American machine will be about double the low voltage machine cost.

4. Vapor pressure—Like any vacuum metallurgy process, electron beam welding has limitations imposed by vapor pressure. Some elements have their triple point above the pressures present in the welding chamber and therfore sublime without melting. All critical insulators must be protected from vapor deposits by shields.

What process can do

Equipment has become available so recently—and still is so much in the development stage—that the full possibilities of electron beam welding are as yet unexplored.

Types of welds. It was said earlier that successful operation of the process may depend on work shape and joint design. More experience must be gained in this area. Edge and butt seam welds and spot welds have been made. Straight seams and simple circular seams are best. At the present time it is probably best if the edges of the material are upset in some manner so as to obviate the need for filler wire. No welds have been made with filler wire as yet; seam followers and wire feeders will require high accuracy, particularly when used with a welder having a hot spot less than 1/16 in. in dia.

Materials. The materials usually considered hardest to weld generally lend themselves readily to the electron beam process, while some of the easier-to-join metals may give difficulty. Zirconium and other materials —aluminum, beryllium, columbium, molybdenum, nickel, stainless steel, tantalum, titanium, tungsten and uranium — have been successfully welded. Although some of these do not fall in the reactive or refractory class, there are still advantages to be gained if very thin sections must be welded. Some dissimilar metal combinations have been welded: aluminum to stainless steel, for example. Almost any metal can be welded with the exception of those having a very high vapor pressure at their melting point. The most common elements in this class are cadmium, magnesium and zinc. However, copper and manganese may also create some problems. Some grades of carbon steel contain so much gas that the welding area tends to explode, and a very poor seam results.

Sizes. This, of course, is a matter of equipment. A specimen welded with the high voltage welder consisted of 4 bars which were 4 in. long, 0.500 in. wide and 0.250 in. thick. One model of the low voltage welder will handle parts up to 3⅛ in. in dia and 10 ft in length. On another model, circular welds up to 8 in. dia and longitudinal welds up to 4 in. long can be made by modifying the unit. As for thickness, it is a matter of power. Sample welds have been made on parts as thin as 2-mil zirconium foil. One model has a maximum wall thickness rating of ⅜ in., another can be furnished with a gun which will weld 1-in. plate if necessary.

Applications

For the high voltage process, the major advantage is the welding of reactive and refractory materials required for the rocket and nuclear fields. The Bettis Atomic Power Div. foresees, as an ultimate application, joining assemblies of uranium-bearing fuel elements clad with zirconium-base alloys for pressurized-water nuclear reactors. Another application: metallic cladding has been sealed around nonmetallic fuel samples to be inserted into in-pile radiation tests. Other fusion welding processes resulted in objectionable contamination of the cladding and weld with fuel alloy.

With the low voltage process, such metals as stainless steel can be better welded than with other methods, particularly when joining thin sections or joining thin sections to heavy ones. Another application area of importance is the closing of vessels without the problem of internal gas pressure buildup.

Other possibilities:

1. Complex fuel assemblies for nuclear reactors might be evacuated and welded in a single step, providing highly corrosion resistant welds.

2. Titanium-stabilized superalloys might be welded without the change in titanium content in the weld which often lowers the creep strength at the joint.

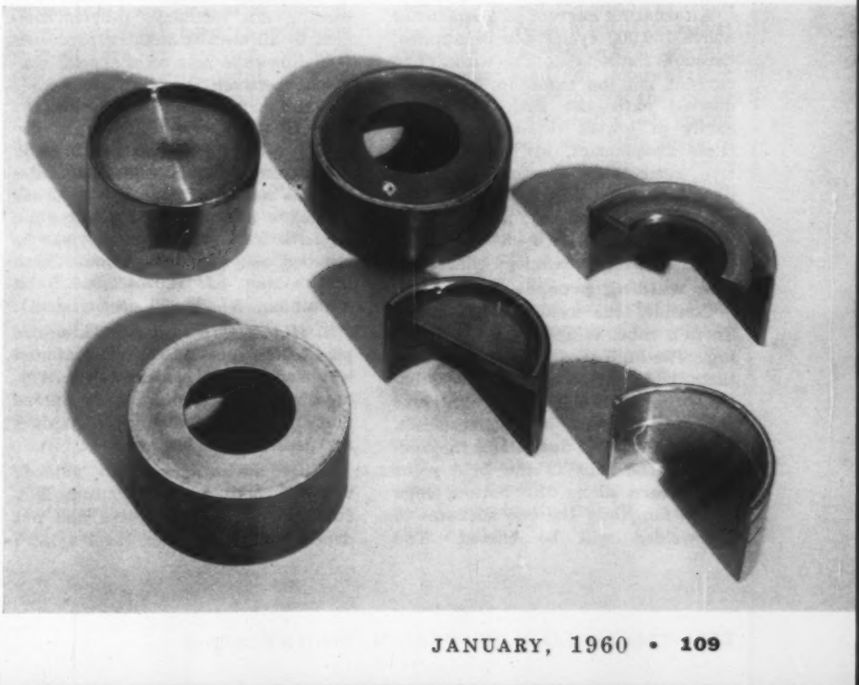
3. Beryllium assemblies might be welded without using organic bonding materials or complex fasteners.

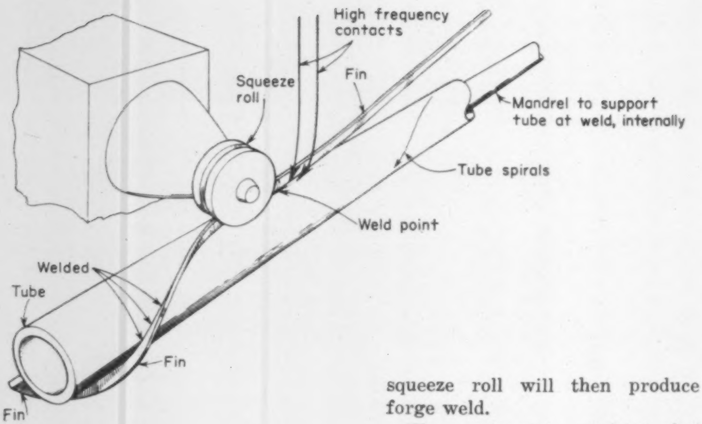
4. Refractory metal thermocouples might be fabricated quickly with reproducible characteristics.

5. Copper and copper alloy assemblies for electron tube parts might be welded with improved cleanliness, eliminating the need for post-weld chemical cleaning.

Reactive and refractory metals *are joined with welds of high purity by electron beam welding.*

NRC Equipment Corp.





High frequency resistance welding

High frequency resistance welding is particularly advantageous in forming butt, lap and mashed lap seam welds on strip, tube and spiral tubing of any weldable metal.

High frequency electrical energy can heat materials in three ways—through induction, dielectric or resistance effects. As applied to welding, resistance heating is the newest of these methods.

The theory

Alternating current of frequencies above 100,000 cycles can be applied, through contacts, to the work. The current can be made to flow in a desired path—the path not necessarily of lowest resistance but, at these frequencies, of lowest inductive reactance. Maximum current density is on the surface of the conductor ("skin" effect), and the current flows in a path closest to the return path ("proximity" effect).

The welding process

Consider the welding of a spiral fin to a tube, as shown in the drawing. The high frequency sliding contacts, which are the key to the process, bring in a 450,000-cycle current just in advance of the squeeze roll. The current will flow along the surface of the tube to the weld point and return along the bottom edge of the fin. Only the two surfaces to be welded will be heated. The squeeze roll will then produce a forge weld.

The equipment consists of two parts: the source of high frequency energy (vacuum tube oscillators) and the accessory transformer and contacts which mount on the welding mill. Currents range to more than 2000 amp.

Advantages

The major advantages of high frequency resistance welding which always apply to any job are:

1. The existence of a localized heat zone. The localized heat zone is made possible by controlling the path of the current, and by the "skin" effect which means the current flows only to a depth of a few thousandths of an inch. Thermal conduction may cause heat below this surface but at fast welding speeds there is not enough time for significant deep heating.

2. Metallic oxide coatings are no longer a current barrier. The oxide coating—an "insulator" problem common to all electric welding processes—in this case acts as a special conductor between the sliding electrode and the metal beneath the oxide. At high frequencies the current is carried into the metal by a combination of unusual electrical effects. Because there is no need to attempt to crush the oxide coating, light pressures can be used. Thus, thin materials can be handled without collapse and with long contact life (200-400,000 ft on aluminum, 50-100,000 ft on steel).

3. High welding speeds. These are possible because of the efficient and localized heating which occurs. Aluminum tubing is production welded at 250 fpm; steel tubing (⅜ in. dia) at speeds over 400 fpm.

Other advantages often gained: welding speed per unit output is a function of wall thickness and not dependent on diameter (over 1 in.); little adjustment is required in changing to another material; internal beads are smaller; and there is less flash and internal splatter.

What process can do

The process is currently being applied mainly to tube and strip welding, mostly because of the market possibilities.

Types of welds—Three basic types of welds are being accomplished: butt, lap and mashed lap.

Materials—Any weldable material can probably be welded by high frequency. Metals that have been welded include aluminum, brass, silicon bronze, copper (including 100% conductivity), Incaloy, Inconel, molybdenum, monel, nickel, stainless steel, hot and cold rolled steel, titanium and zirconium.

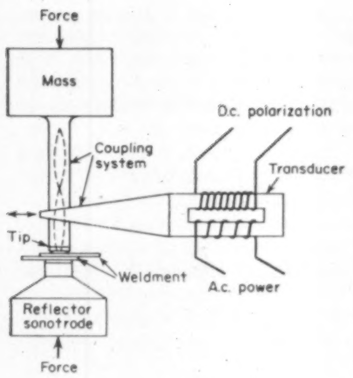
Types of weldments—Seam welded tubing is the major type of weldment that has been produced. Seam welded strip has also been produced. Spirally welded tubing, made from plain or perforated strip, has been made with a mill small enough to be portable. (The mill can be switched from one diameter to another by changing the cylindrical mandrel.) Spiral fins have been welded to tubing, as shown in the drawing. These are only a few of the continuously welded shapes possible.

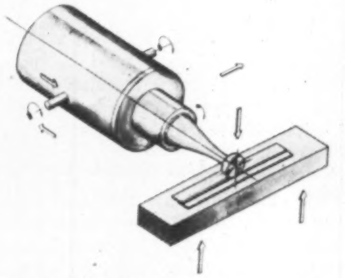
Sizes—Tube diameters have ranged from ⅜ in. to 16 in.; walls from 0.008 to ⅜ in.; strip thicknesses from 0.004 to ⅜ in. Equipment is being built to weld heavier thicknesses up to ⅝ in.

Applications—With some types of aluminum tubing, the process is competitive with extruding, but aluminum alloy tubing of high tensile strength, not produced by extruding, is also easily welded by this method. Welded copper tube of 100% electrical conductivity meets the specifications for the best refrigeration grade of pierced and drawn tube. Another copper welding task is the cable being considered for the next transatlantic telephone cable; now the copper tube surrounding a steel core can be welded without heating the steel.

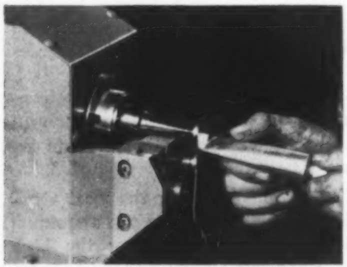
Other current applications include: containers, cans, lamp posts, filters, well casings, mufflers, bandsaw blades, decorative trim, furnace water-wall tubing, heater tubes parallel to tubes carrying viscous liquids, irrigation pipe, and zirconium finned tubes for nuclear reactors.

Ultrasonic welding





Continuous-seam head *has transducer-coupling system which allows travel and rotation in arrow directions. Welding tip rotates at peripheral speed equal to weldment travel.*
Aeroprojects, Inc.



Aeroprojects, Inc.
Ultrasonic seam welding *closes ends of aluminum squeeze tubes.*

Aeroprojects, Inc.
Hermetic sealing *is an important use of ultrasonic welding.*

Ultrasonic welding, though mostly used for aluminum joining at present, can be used for most metals, including dissimilar combinations involving such metals as titanium, zirconium, and thin gages of beryllium and molybdenum. Spot, seam and ring welds are made on materials of thicknesses ranging from less than 0.0002 in. up to 0.1 in., the upper limit depending on the alloy and determined by the thinner piece.

Like some of the other processes described in this report, ultrasonic welding is a solid-state metals joining method which uses no fluxes or filler metals. The use of ultrasonic energy is not new—it has been applied to cleaning, testing and other tasks—but interest has increased in recent years. Application to welding began with its use in conjunction with resistance spot welding and developed from there to the present practical art.

The theory

The theory is relatively simple. It was found that the close contact and friction developed with the passage of high frequency vibratory energy through two abutting metals would cause them to adhere together without the use of welding current. In most cases, it is not necessary to apply heat.

The process

The workpieces are clamped together under moderately low static force, and ultrasonic energy is transmitted into them for a brief interval. A metallurgical bond is produced without arc or sputter, without fusion of the weld metal, without the cast structure resulting from fusion, and with negligible thickness deformation.

The significant variables during the welding operation are the applied clamping force, the power level, and the weld time for spot-type welding, or the welding rate for continuous-seam welding.

These three factors cannot be determined separately for a given combination of materials, since their interaction is important in the bonding process. The particular settings for a given application depend primarily upon material properties and thickness. Clamping force may vary from a few ounces to several hundred pounds. Electrical power input may vary from milliwatts to several thousand watts. For spot welds, the weld time is usually in the range of 0.01 to about 1.2 sec. For continuous-seam welds, welding rates as high as several hundred feet per minute may be obtained with thin foil material. In general it has been found that high power and short weld times produce better results than lower power and longer weld times. In addition, there is an optimum clamping force at which effective bonding of a given material combination is achieved with minimum vibratory energy.

Surface cleaning is not critical in preparation for ultrasonic welding of most materials. The more readily weldable materials, such as aluminum, copper, and brass, can be welded in the mill-finish condition and require only the removal of surface lubricants in a detergent solution. Welding of materials containing heavy heat-treat scale is more readily accomplished after mechanical abrasion or descaling in a chemical etching solution.

Spot welding equipment ranges in power from 25 to 4000 w, and includes both bench and floor models. Continuous seam welding equipment ranges from 100 to 2000 w. Heavier duty equipment is under development for both types of welding. Modifications in standard equipment can be made.

The basic equipment components include: a power supply and driving unit; an ultrasonic-transducer coupling and its force-insensitive mount (to prevent energy loss to supports); a reflector anvil for concentrating vibratory energy within the work; a hydraulic, pneumatic or spring system for applying static force to the weldment; and an electronic timer to control the duration of the ultrasonic pulse.

Advantages and limitations

Some of the advantages of ultrasonic welding are:

1. Temperatures are kept well below the melting points of the metals, thus preventing contamination. The temperature rise which occurs can be controlled within limits by appropriate adjustment of the welding machine settings.

2. It permits sound junctions to be obtained between many dissimilar metals previously difficult or impossible to join.

Westinghouse Electric Corp.

Dissimilar metal strips *can be joined rapidly by ultrasonics.*

3. Intermetallic combinations are seldom formed in the weld zone of dissimilar metal junctions.

4. With no current passing through the weld zone, there is no arcing or sparking to contaminate surrounding areas.

5. Thin foil or fine wires can be joined to themselves or to larger and heavier components.

6. A wide variety of configurations can be effectively welded.

7. Helium-leaktight seam welds can be reproducibly obtained.

8. The process and associated equipment can be readily incorporated in automated production lines for many applications.

Some of the limitations of the process in its present state of development are as follows:

1. With any given material there is an upper thickness limitation for the production of sound welds with currently available equipment.

2. Techniques have not yet been developed for producing butt welds with ultrasonic welding.

3. The process may not be economical for bonding materials that can now be readily and satisfactorily bonded by other techniques.

What process can do

Ultrasonic welding has progressed at a rapid rate in terms of expanding its capabilities. There are no great materials problems, and maximum limitations on sizes and thicknesses (which apply to the thinner part) are largely a matter of producing larger, heavier equipment with an increased power source such as might come from motor-generator sets. Transducer-coupling systems, capable of handling greater power, are constantly under development and, as the problems associated with greater power transmission are solved, the thickness limitations are progressively relaxed.

Types of welds. The following types can be accomplished with this process:

1. Spot-type welding, in which individual weld spots, approximately elliptical in contour, are produced by the momentary introduction of vibratory energy into the workpieces.

2. Spot-seam welding, in which an essentially continuous bonded area is produced by a succession of overlapping spot welds, usually about 5-10 welds per in.

3. Ring welding, in which an uninterrupted annular weld is produced with a single impulse of the welding equipment. This is new and the possibilities are currently being explored.

4. Continuous-seam welding, in which the seams are produced with the workpieces clamped between a rotating cylindrical or disk-shaped tip and traversing table or roller-type anvil. Three variations of continuous-seam welding are: a) roller-roller welders in which the workpieces pass continuously between two rollers, one or both of which may be ultrasonically activated; b) traversing-bed welders in which the work passes under an active welded disk tip; c) traversing-head welders in which the tip rotates and traverses the work.

5. Area welding, in which continuous-seam welds are overlapped to produce total bonding over an extended surface area.

Materials. Among the most readily weldable materials are aluminum and its alloys, including the high strength structural alloys such as 2014, 2024 and 7075. They may be joined in any form—cast, extruded, rolled, forged—and after any type of heat treatment. Soft aluminum claddings on the surface of these alloys facilitate bonding.

Copper and its alloys, such as brass and gilding metal, and other comparatively soft metals, are relatively easy to weld. No particular difficulties have been encountered with precious metals such as gold, silver, platinum and alloys of these materials.

Satisfactory bonds can be produced in iron and steels of all types, including ingot iron, low carbon steels, nonhardening steels such as the austenitic stainless steels, tool and die steels, and precipitation-hardening steels. Nickel and its alloys, including Inconel, Hastelloy, monel, Kovar, etc., can also be welded, although difficulties are encountered with some of these.

Among the high temperature refractory metals, titanium and zirconium alloys are the most readily weldable. Tungsten, tantalum and molybdenum, as well as beryllium, can be satisfactorily joined in thin gages.

Bimetal junctions of many of these materials are also feasible and practical. Aluminum can be welded to almost any of the above metals; copper, brass and steel can be welded to many of them. Combinations such as aluminum, copper, platinum, and gold to silicon or germanium are readily achieved. Other feasible bimetal welds include various combinations of molybdenum, nickel, tantalum, titanium, zirconium and tungsten.

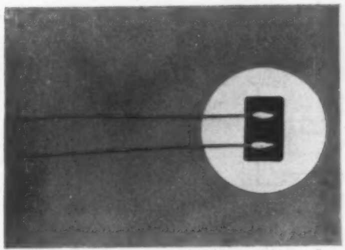
Types of weldments. Spot or seam welds can be made with overlap joints or butt-splice joints. Thin foil, wire or ribbon can be welded to heavy sheet, plate or block. Wires can be joined together; thin foils may be welded to themselves; small ribs have been welded to flat sheet and also to tubular members in a spiral configuration. Often the welding tip and anvil can be modified to facilitate joining of unusual configurations.

Sizes. Aluminum is weldable in sheet thicknesses up to 0.1 in., structural aluminum alloys up to about 0.063 in., and some of the harder metals up to 0.02-0.04 in.

There appears to be no lower limit to the weldable thickness of a given material, since successful welds have been produced with fine wires of less than 0.0003 in. dia and with thin foils less than 0.0002 in. thick without rupture of the material. Components of widely differing thicknesses can be joined, and machine settings are determined by the thinnest member of the weldment, provided this member is adjacent to the welding tip.

Applications

Ultrasonic welding permits joining a wide variety of joint geometries for many specific applications. Spot welding may be used to produce a conventional structural bond or for applications in which mere attachment of the component is the primary requirement. Spot-seam or continuous-seam welding is effective where a continuous bond is required, either for strength purposes or for hermetic sealing of components, as in packaging. Ring welding can also be used for hermetic sealing, as in capping small tubular members or for other applications in which an annular weld is desired. Area welding can be used where bonding over an extended area is required, as in the cladding of one material to another.


Aeroprojects, Inc.

***Aluminum lead wires** are joined to silicon semiconductor elements by ultrasonics.*

Industries and products. Here are some of the specific areas in which ultrasonic welding has been successfully applied:

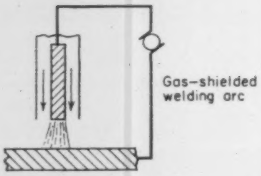
1. Structural applications in automobiles, nuclear reactors, aircraft, missiles and rockets.
2. Electrical applications, such as the attachment of leads to transformer coils; of contact buttons to sheet, plate, or ribbon; of stranded aluminum wire to copper terminals.
3. Electronic applications, particularly for joining miniaturized components that are difficult to join by other methods. These applications include attachment of leads to semiconductor materials; assembly of bridgewire or electrical match components; bonding of components for electronic tubes; welding of leads to high-temperature printed circuit boards; hermetic sealing of electronic components requiring special atmospheres or freedom from contamination. Junctions of extremely low ohmic resistance are made by this process.
4. Packaging applications, particularly the hermetic sealing of metal foil packages of various sizes and shapes; e.g., sealing of aluminum cans and squeeze tubes, and the packaging of foods, drugs and the like. Such packages have been found leaktight to the limits of detection of helium-leak test equipment.

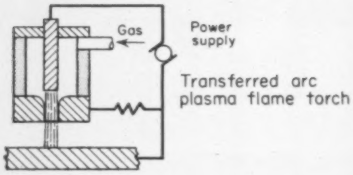
Future. The range of welding thicknesses and the variety of weldable metals, particularly in dissimilar combinations, will continue to expand. The applications in which ultrasonic welding is effectively used are constantly growing, and there is every reason to believe that within the next few years the process will be successfully used on a production basis for many presently unforeseen applications.

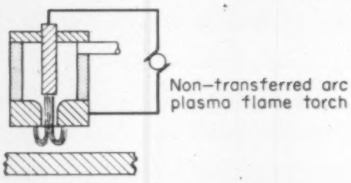
DISSIMILAR METAL COMBINATIONS WELDED BY ULTRASONICS[a]

Metal → ↓	Aluminum	Copper	Germanium	Gold	Kovar	Molybdenum	Nickel	Platinum	Silicon	Steel	Zirconium
Zirconium	X	X				X				X	X
Steel	X	X				X	X	X		X	
Silicon	X			X							
Platinum	X	X		X	X		X	X			
Nickel	X	X		X	X	X	X				
Molybdenum	X					X					
Kovar	X	X		X	X						
Gold	X	X	X	X							
Germanium	X										
Copper	X	X									
Aluminum	X										

[a] The presence of blanks does not necessarily mean that such a welding combination is impossible or impractical. In most cases the combination has not been attempted or studied.







The Arc Plasma Torch

The arc plasma torch is not a welding method—it is a means of heating metals.

This process is included here because it may have important applications in fusion welding, and because equipment has become available in the last few years which allows the principle to be applied to two fields closely allied to fusion welding: metal cutting and metallizing.

The theory

A plasma is an ionized gas. True plasmas are totally ionized and require temperatures presently above practical limits; the word is therefore being applied to the partially ionized gas producible by present equipment.

The term "plasma" also is understood to refer to a "plasma jet." Any high current arc is comprised of plasma; when the plasma gas is forced through a nozzle it becomes a plasma jet.

Plasmas may be produced by several methods. For example, as gas in the intensely hot region behind a shock wave will partially ionize to form a plasma. However, present attention is being devoted to the use of an electric arc as a plasma generator.

The process

There are two basic types of the modern plasma jet device:

Transferred arc—In this case both the arc and the plasma stream continue on to the work after leaving the nozzle. This is actually an extension of the open welding arc principle and is used for metal cutting.

The main difference between an arc plasma torch and the conventional electric arc is that the plasma is capable of producing maximum gas heating while heat losses to the anode are held to a minimum. The open arc transforms most of its electrical energy into anode heating; for this reason it is doubtful that the plasma flame will supplant the open arc as a major heat source for fusion welding. On the other hand, there may develop special cases of flame fusion welding which demand the higher heat transfer from arc to gas.

Although the transferred-arc torch is capable of heat transfer rates of 200 Btu/sq in./sec, they must be achieved with high jet temperature and high jet velocity. In welding, the high jet velocity would blow away the liquid metal pool unless it is reduced to below-sonic velocity. In the limit, it approaches the open arc at its lowest kinetic levels.

Non-transferred arc—In this case the arc is forced into, and possibly through, the nozzle by the flow of gas. However, the arc ends on the nozzle and the hot gas keeps going to the work. This type of plasma jet may be compared with the oxy-fuel flame and is the basis for metallizing operations.

Plasma flame temperatures for the non-transferred arc reach 30,000 F (vs 60,000 F for transferred arc). Heat transfer rates approach 60 Btu/sq in./sec as compared with 10 Btu/sq in./sec for the oxyacetylene flame. Any gas that does not attack the tungsten cathode can be used. Such gases include argon and helium, as well as nitrogen and hydrogen.

As for equipment, a complete plasma flame system consists of a torch, control console and d.c. power supply (motor-generator set or rectifier). The torch design is predicated on minimum electrode erosion, but major problems are involved here and presently available equipment is far from being a universal tool.

Advantages

The major advantages provided by application of the principle of arc-constricting nozzles are:

1. *Arc-flame stability.* The plasma goes in the direction it is pointed, even at relatively low gas flows.

2. *Concentration of power.* Of importance in metal cutting where it is best to make the kerf as narrow as possible.

3. *Concentration of momentum.* Valuable in accelerating metal particles to be deposited or in ejection molten metal from a cut.

4. *Heating of gas and powder.* Material is highly heated because it is forced through an arc rather than around it.

5. *Low operating costs.* However, the high equipment costs of the plasma devices must be amortized.

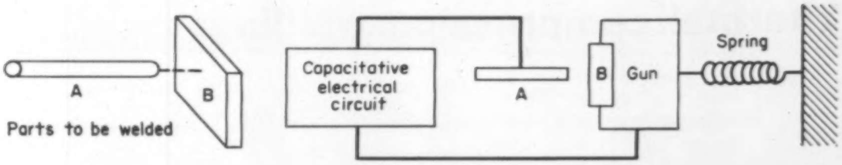
What process can do

The modern plasma torch is so new that there are, as yet, only a few industrial applications.

Metal cutting—The work must be melted, and the transferred arc does this with high efficiency. For example, ¾-in. steel plate has been cut at 72 ipm at a cost lower than that of oxyacetylene cutting which has a maximum cutting speed of 25 ipm for the same thickness. Thicknesses up to 2½ in. of steel can be cut satisfactorily.

Metallizing—Here the work should remain as cool as possible. Therefore the arc is ended on the nozzle, i.e., the non-transferred type is used. Plasma is competitive with the conventional flame over the whole range of metallizing and spraying processes. Tungsten, tungsten carbide and other refractory metals have been sprayed.

Other—Another large area under investigation is aerodynamic and materials testing. For example, the plasma jet may simulate, in the laboratory, the severe heating and ablating conditions of nose-cone re-entry. As for welding, it remains to be seen.



Percussion welding

Percussion welding finds its main application in joining close-tolerance small parts of such electrical contact materials as gold, silver, nickel-silver, copper and palladium.

Percussion welding is not new—the technique has been studied and modified in various ways since before the turn of the century—but it has seen only limited production use. A capacitative circuit charged to a high potential (often several thousand volts) is discharged across the gap between parts as they approach each other under a propelling force. The arc produced heats the surfaces before they collide so that a thin layer of metal is brought to welding temperature. The propelling force continues to act and brings the parts together percussively to make the weld.

Today two variations—high voltage and low voltage—are being used in production. A typical example of each of these will be described.

High voltage process

A proprietary automatic machine has been developed which uses this principle to weld contacts to wire spring relay blocks. The weld energy is controlled by the capacitance included in the welding circuit, the voltage (1000 v or more) to which the capacitors are charged, and the duration of the arc. Heat of the arc melts back the tip of the projected member at a faster rate than the part is moving forward. The arc is thus able to spread over the whole mating area and melt a thin layer, perhaps 0.005 to 0.015 in., in both parts. The arc is extinguished after 150-600 μsec by physical contact of the molten surfaces.

Problems—The major problem is to control the energy, or, indirectly, the duration of the arc. This energy is a function of: 1) separation between the electrodes; best control has been obtained with flat-ended wires and voltages above 1000 v; 2) material evaporation which increases the arc length (difficult to predict); 3) formation of metal filaments which bridge the gap and extinguish the arc; currents should be decreased as the surfaces approach each other. Analysis of these problems has resulted in a welding circuit which is essentially a capacitative transmission line approximated by two or more r-c sections.

A second area in which more work is needed is that of materials and design. It is necessary to select materials which are reasonably compatible (weldable without irregularities such as gas pockets) and geometries which allow each part to reach the desired temperatures (above their melting points and below their boiling points).

Advantages

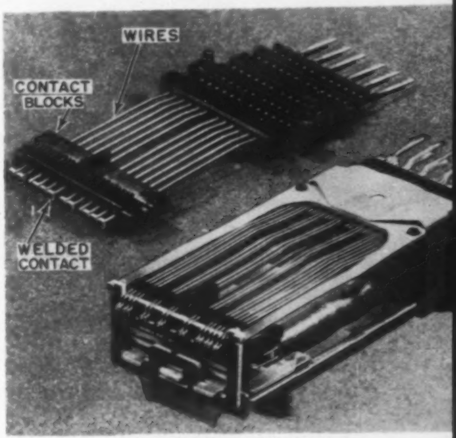
1. The arc potential of approximately 15 v permits the addition of considerable energy in a short time.
2. Welding electrodes can be placed well away from the weld zone without overheating the adjacent areas.
3. The problems of compatibility between materials and geometries are not as great as in resistance butt welding.
4. Weld strength approaches the intrinsic strength of parts.
5. The process is fast and adaptable to high speed automation.

Application: The particular job being done with the automatic equipment that has been discussed is the welding of small metal blocks bearing palladium contacts to flattened ends of 0.0400-in. dia nickel silver or other nonferrous alloy wires molded in a single comb. All palladium contact surfaces are located in the same plane across 12 wire positions within a tolerance of ±0.0002 in.

Other applications of high-voltage percussion welding, mainly in the field of electrical contact materials, are being investigated.

Low voltage process

This method involves the same principles as the high voltage equipment but uses much higher capacitance to compensate for the lower voltage. The advantages of low voltage (50 v) are the personnel safety factors and the lessened danger of damage to components being welded. Establishment of the arc is facilitated by giving one of the mating surfaces a feather edge or sharp point which is melted away. Approach velocities are 80-100 ips (vs 80-150 ips for high voltage), and the arc duration is 150-300 μsec (vs 150-600 for high voltage).



Bell Telephone Laboratories

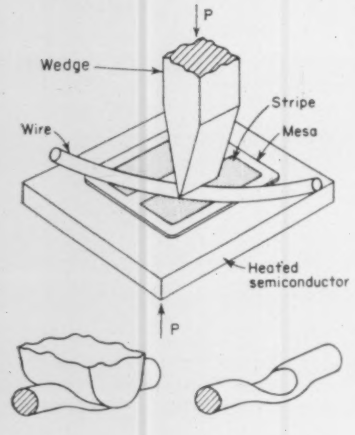
Wire spring relays *are made by percussion welding palladium and cupro-nickel contacts to silicon-copper wire combs.*

Advantages

1. Refractory and high conductivity metals are readily weldable.
2. Rapid heating, limited to arc area, requires low energy.
3. Heat penetration is minute.
4. Surface conditions are unimportant.
5. Welding may be done in close working areas.

Application. A hand gun has been developed for using this process to connect wires to electrical terminals. Wire sizes from 0.006 to 0.102 in. have been welded. Both copper and aluminum wires have been welded to a variety of metals. A semi-automatic welder has been built and an automatic welder is being designed to weld two 0.012-in. tinned copper wires to the nickel-iron terminals of a dry reed switch.

Thermal compression welding



Thermal compression welding is a simple bonding method which uses heat and pressure to join extremely tiny parts. It was developed for one particular application—joining tiny wire conductors to transistor semiconductors—but has a wider potential.

The process brings to light basic principles of bonding which call for further study and application, such as in the areas of forge and friction welding.

The theory

With heavy pressure, obtained with light force when parts are tiny, cold welding of two smooth surfaces will occur due to deformation and plastic flow near the actual contact points (microscopic projections). Elastic springback may cause them to break apart when pressure is removed, but if one is a soft metal this will not occur. The junctions may be stronger than the materials.

Metals, of course, have films of various kinds, principally hard oxides. Applying limited heat will keep the junctions from becoming too brittle.

The welding process

Surfaces should be free of films. The wire is generally chemically cleaned before bonding. Transistor electrodes are satisfactorily clean as they come from the alloying process. Using a microscope to view the process, the wire is fed over the heated semiconductor and a wedge is brought down to exert a force on the wire which is flattened and bonded to the semiconductor electrode (see drawing). The bonding process is best performed with a surrounding protective atmosphere of inert gas, though bonds have been made in air. The process lends itself to automation. In bonding a wire to an electrode, the variables which must be properly controlled are time, temperature and the yield pressure, which is a function of tool shape and bonding force. It has been found that time is inversely related to bonding force or temperature and, to make the process fast, could be kept below 5 sec.

Determination of other variables is best done by following these rules:

1. Choose appropriate lead material. Soft, annealed metals minimize the elastic stress.
2. Keep wire diameter about half of the limiting dimension (after flattening has occurred).
3. Make tool radius about equal to wire radius.
4. Choose appropriate temperature range, i.e., within the annealing range of the metals but below eutectic or alloying temperatures.
5. Optimize bonding force by experiment.

As an example of optimum pressures and temperatures determined by experiment, 15,000 to 25,000 psi, 570 to 660 F, and a 5-sec time interval are appropriate for forming a bond between gold wire and a block of germanium. Where metal-to-metal bonds are to be made, the bonding time can be reduced.

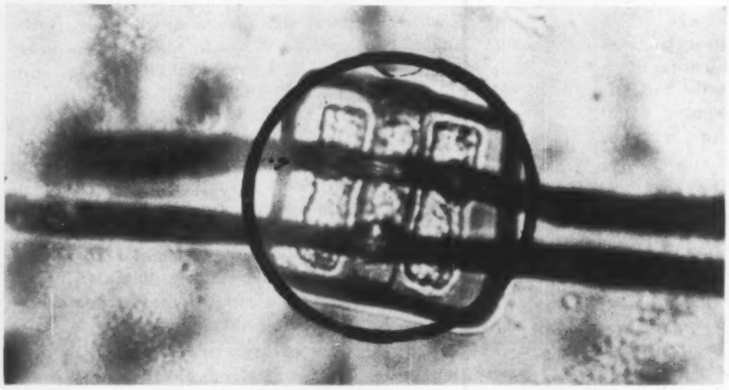
What process can do

Miniaturized electronic devices, transistors, high frequency—all have created mechanical problems in handling tiny parts. In addition, in fabrication, semiconductors are frequently sensitive to mechanical disturbances and minute traces of chemical contamination. One of the outstanding problems has been to secure a bond between thin electrical conductors and the semiconductor. The bond must be accurately positioned; must have little effect on the electrical characteristics of the semiconductor; and must be mechanically strong. Thermal compression bonding has met these requirements.

Materials. Gold wires have been production bonded to semiconductors such as germanium and silicon. Other materials bonded include alloys of silver, aluminum, copper, platinum, tin and lead. The harder noble metals, like palladium, are more difficult to bond.

Sizes. An average power transistor uses gold lead wires 0.002 in. in dia. The photo illustrates a bond made with gold lead wire of 0.0004 in. to a high-frequency germanium diffused-base transistor with elements of evaporated and alloyed gold and aluminum. The emitters are metallic films about 0.006 by 0.001 in. in size, 1500 to 3000 Angstroms thick, and are spaced from 0.5 to 1 mil apart.

Another application. The theory might be extended to introduce a liquid-phase eutectic into the process. In this manner, an electrode and a lead could be formed in one operation. Control of alloy depth is feasible.



Bell Telephone Laboratories

Joints of tiny wires *are required when producing transistors. Here gold wires have been bonded to gold and aluminum elements of germanium semiconductor base. Circle is size of human hair.*

Miscellaneous welding processes

Capacitor discharge welding

A new process based on the principle of percussion welding brings tiny parts together under a mechanical force after discharging a simple capacitor bank across the joint to effect melting of the metal.

Voltages are below 440 v and heating takes place in 0.0005 sec. The heat-affected zone is about 0.001 in. wide.

Dissimilar metal joints are readily made with such difficult combinations as tungsten to beryllium copper and tantalum to aluminum. Two combinations that cannot be joined: tungsten to tungsten, and leaded brass. Cold work and heat treat properties are maintained.

A typical application is welding 0.039-in. tungsten carbide balls to a stainless steel screw for a gyro thrust bearing. Although used mainly for such tiny parts, and for butt welding fine wires, the process has also been used to butt weld rod of annealed aluminum up to ¼-in. dia.

Capacitor discharge bonding

Another process discharges a capacitor across a metal foil inserted between two semi or nonconducting materials such as ceramics. In this case the discharge vaporizes a tiny bit of metal to form the weld with very little heating of the bond pieces. Metal foil beyond the bond area dissipates into the air. The voltage used is 8000 v, discharged through a spark-gap switch. The condenser discharges in a few microseconds. Quartz rods of ⅜-in. dia have been bonded with 0.001-in. thick tantalum foil with a resultant tensile strength in excess of 2000 psi. Silicon-to-copper bonds have been made using 0.002-in. brass foil. The process has also been used to sinter graphite and other materials.

Diffusion bonding

This process has two basic variants. It is either a brazing method or a solid-state welding method, depending upon whether or not an intermediate layer of metal (0.1 mil thick) is used.

'Brazing' method. If such a layer is used, it forms a eutectic with the base material and a liquid is formed which diffuses into the base. This is similar to brazing with the eutectoid formed-in-place in the joint. Research in this area has concentrated on the joining of Zircaloy-2 for fuel element cladding in pressurized-water nuclear reactors.

Many materials have been tried for the intermediate layer, at temperatures ranging from 1650 to 2550 F and pressures sufficient to obtain contact of parts. To date the most successful seem to be copper, nickel, nickel-phosphorous, manganese and silicon.

Solid-state method. In the solid-state process, bonding occurs by movement of atoms or intermetallic compounds across the interface. Temperatures are generally below 1000 F and pressures range from 4000 to 8000 psi. The time for diffusion to occur depends upon the metal and may range from 20 min to 3 hr.

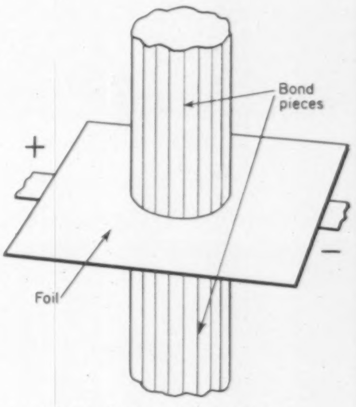
One advantage of the solid-state process lies in the ability to produce joints with the same approximate microstructure as the base metal, providing similar physical and mechanical properties. The process may also be used to join special alloys where conventional welding processes are not suitable, particularly where post-joining heat treatment is required.

Materials that were successfully welded by the solid-state process in one experiment were nickel to copper and iron. Another experiment conducted at 650 F obtained good joints with beryllium copper bonded to monel, and with gold bonded to copper, silver, aluminum and lead, although the last two materials yielded brittle joints. With some metal combinations, a plating of nickel, gold, copper or other metals is first deposited on the surfaces to be joined. Such was the case with the monel-beryllium copper weld.

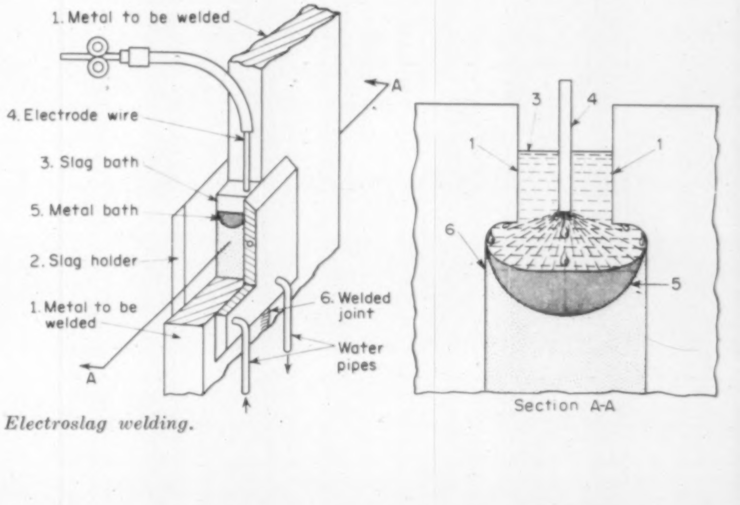
Applications. Titanium-titanium, steel-steel and copper-brass are three potential combinations now being investigated. In general the most promising applications lie in the joining of parts to be used at high temperatures.

Electroslag welding

The key to this Russian-developed process is that heat is obtained by passing electric current through a bath of molten slag. A melting electrode wire (flux-cored in the latest welder introduced here last month) is fed continuously into molten slag held between the edges of the com-



Capacitor discharge bonding



Electroslag welding.

ponents to be welded and water-cooled copper plates.

Parts as thick as 2⅜ in. can be welded with one electrode. If the electrode is reciprocated normal to the plane of the welded parts, welds of 6 to 8 in. in thickness can be obtained, although about 4½ in. max is recommended for reasonable welding speed. By increasing the number of electrodes, parts of almost unlimited thickness can be welded. On the average, parts that have been electroslag welded range from 2 to 12 in. in thickness. The process can be readily adapted to welding vertical butt joints, T joints, corner welds with inside fillets, girth seams in heavy wall cylinders, and for building up large surfaces. The metal deposition rate may run as high as 45 lb per hr for a single electrode; 135 lb for the triple electrode machine recently introduced. In 2-in. thicknesses the weld is made in one pass at 4 to 6 ft per hr.

Forge welding *is an economical way of producing aluminum wheel rims. Temperature, pressure and time are carefully controlled.*

Ravens-Metal Products, Inc.

Other advantages, in addition to the fact that welding speeds are much higher than for competitive submerged arc welding, include: lower flux costs, less handling, mobility of the welder, and easy operation.

Limitations of the process include: the coarse structure of the metal weld deposit; the presence of a large heat-affected zone adjacent to the weld; and in welding quenched and tempered steels, some loss in notch toughness due to the slow heating and cooling.

Materials that have been welded are limited to the carbon steels, certain types of low-alloy high-strength steels, and stainless steels. It is believed, however, that the process will eventually be applicable to any weldable metals, and advantageous in thicknesses above 2 in.

Foil seam butt welding

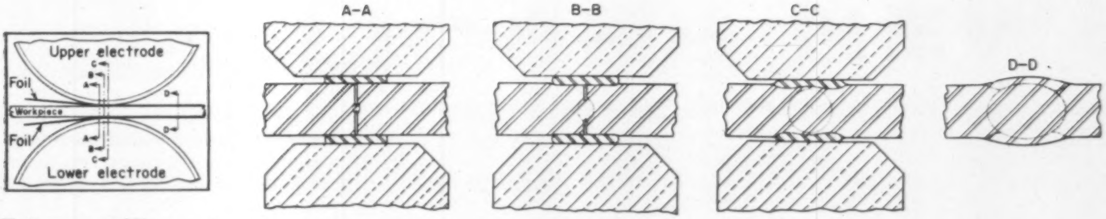
This process was developed in Europe for particular applications where high speed and freedom from distortion are important. It has future potential because of these advantages and because little or no finishing of the weld metal is required.

Foil seam welding is a resistance welding process which produces butt joints in flat strips. Thin foil strips are placed over and under the square mating parts of the butt joints to be welded. These foil strips range in width from 5/32 to 3/16 in. and are from 0.007 to 0.010 in. thick. They are actually pressure welded into the fused area.

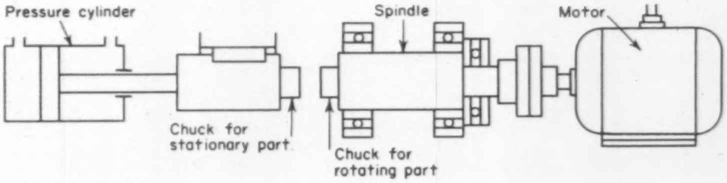
As the work and foil are rolled between the electrodes, a small nugget is formed which gradually increases in area (see drawing). On 0.087-in. stock, welding speeds range from 3 to 24 fpm. Tests are reported to have shown the welds to be free from defects and to possess high tensile and fatigue strengths.

Materials that can be welded include mild, low alloy, high carbon and stainless steels.

One potential application pointed out by the American company making foil welding machines is the reclaiming of scrap in the automotive and appliance industries. Pieces of scrap can be seam welded together by this process to produce such items as mounting brackets. It is expected that annual materials savings would amount to several times the cost of the machine.



Foil seam welding.



Friction welding.

Forge welding

Recent advances in the old technique of forge welding consist of heating the parts to be welded to a temperature which is high enough to allow good uniform flow of the materials without cracking, and yet low enough so that parts are not overaged or partially annealed in the welding process. Practically, then, the difference between the old and modern technique lies in careful control of time, temperature and welding cycles. As a result, welds have been made in aluminum and magnesium alloys of all tempers with 90 to 100% joint efficiency.

Welding procedures are relatively simple and closely related to those used for making cold welds. Thoroughly cleaned parts are placed in dies with enough material protruding to allow for forging and welding. The faces are brought into contact under light pressure and heated by gas flame or induction. When welding temperature is reached, pressure is applied and the protruding ends are upset and welded.

Pressures used for aluminum have ranged from 30 to 150 tsi, depending on temperature, alloy, amount of upset, and the design of the die and the joint. Heating to required temperature requires from 10 to 30 sec. Temperatures are highly critical, and the optimum value must be obtained for each alloy. For 7075-T6 aluminum alloy, for example, 360 to 440 F was found to be optimum; for AZ31B-F magnesium alloy, 535 to 600 F.

Butt joints have been made on aluminum - aluminum, magnesium - magnesium and aluminum-magnesium combinations. Potential exists in the welding of zirconium and steel to aluminum, and possibly in the welding of such materials as beryllium and molybdenum. There is no particular limit to sizes and thicknesses if equipment is built to handle them. Tests to date have been made on ¾-in. dia bar stock.

Potential applications include large extruded panels for aircraft and transportation products; structural members; chemical tanks; and nuclear and missile applications.

Friction welding

Friction welding is another of the "cold" welding solid-state processes which uses heat to obtain bonding action. In this case the heat is obtained by rotating friction. The same theory is involved here as was discussed under thermal compression welding.

Two pieces to be welded together are mounted in chucks on the same horizontal axis. One part rotates while the other is held stationary. Pressure is applied to generate enough heat to reach fusion temperature. Several seconds are required to generate the required heat which is highly localized. Friction insures the removal of oxide films.

After the fusion temperature is reached, rotation is stopped. The pressure is maintained or increased until the completion of the weld. The weld is allowed to cool in air. Total welding time usually runs from 10 to 25 sec, and the energy that is consumed may be only 10% of that required for a similar weld fabricated by flash welding.

Some inherent advantages of friction welding may be found in the low power requirements and high speed operation. It has potential in the production welding of simple sections because of the lower initial investment costs. However, the process is presently limited to making butt welds of circular cross section parts.

The process is new to this country and little application has been made here. One Russian setup can handle these sizes: diameter from 0.03 to 2 in.; maximum length, 16 in.; length upset, 0.10 to 0.25 in.

Typical values for speed and pressure are 3000 rpm and 1000 to 10,000 psi, depending on the material. Aluminum is welded at 1120 psi, mild steel at 4600 psi, cast iron at 9200 psi.

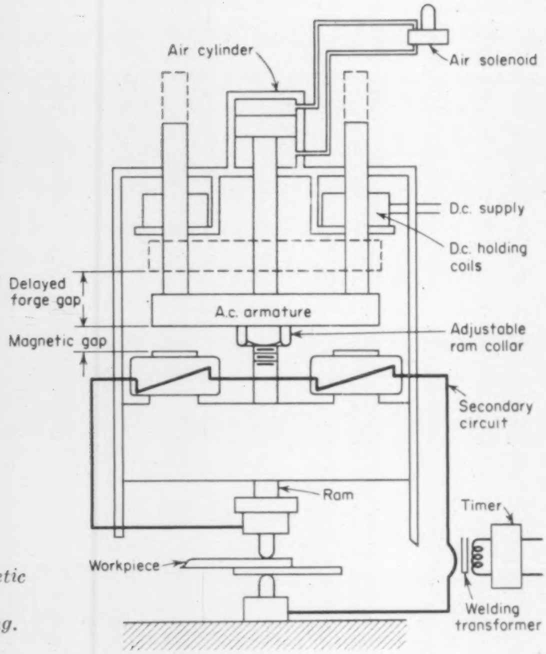
Many materials have been welded by this process—low carbon, medium carbon and free-machining steels, stainless steels, cast iron, brass, aluminum and titanium. Dissimilar metal combinations such as brass to steel, brass to cast iron, and cast iron to copper have also been welded.

Applications include the welding of round bars, flanges, pipe and tubing.

Magnetic force welding

Magnetic force welding allows accurate synchronization of the electrode force and the welding current. This is brought about by coupling the electrode force or pressure with the magnetic force created by the welding current.

The magnetic force welder is generally a conventional direct-acting piston or ram-type spot welder which has been redesigned to accommodate electromagnets for the application of pressure. The air cylinder actuates the ram for positioning of the weldments between the



Magnetic force welding.

electrodes and also imposes a slight initial pressure on the work prior to welding. Final force of the weld is controlled by the gap set by the ram collar. Some combinations of materials need a longer heating period before welding, and for this a d.c. magnet acts to delay forge pressure application. In most applications, the welding time is short, varying from one-half to a few cycles.

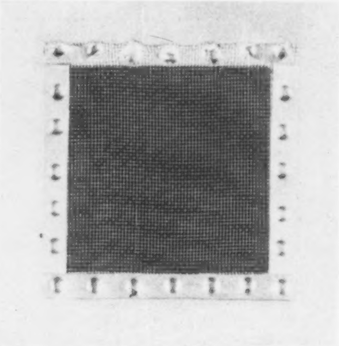
The magnetic force welding process can be used for welding high conductivity metals to each other, and also to carbon steels. Better uniformity and consistency of welds is obtained, resulting in improved electrical characteristics of contact-type joints. Expensive bimetallic contact points can be replaced by less expensive points joined by magnetic force welding at savings up to 50%.

In addition to welding of high conductivity metals for electrical contacts, recent applications include copper commutator assemblies, aluminum-copper tubing joints, mild steel balance weights on malleable iron brakedrums, and vinyl cladding of steel.

Thermobaric bonding

A thermobaric bond has all of the external and few of the internal characteristics of a spot weld. Internal structure at the joint interface consists of discontinuous microscopic areas of coalescence and sharing of alloy impurities.

The process is, at present, a special case developed for one particular application. Aluminum screen or monel mesh is sandwiched between 5052-H32 aluminum sheet and thermobaric bonded on a resistance spot welding machine. The mesh, in a sense, acts as a filler metal, for welding the aluminum sheet to itself. Aluminum 5052-H32 has also been bonded to 5056 by this method. The joint is in many ways comparable to a brazed joint.



General Electric Co.

***Thermobaric welding** joins aluminum retainer, aluminum or monel mesh, and aluminum base on resistance spot welding machine.*

The reason that the joint is not termed a spot weld is that two internal characteristics of the spot weld are not present: a continuous area of coalescence (a weld nugget), and a uniform heat-affected zone (due to heat dispersion, no large area reaches the actual puddling temperature).

Applications at present involve aluminum sheet which is fabricated into electronic equipment chassis, covers, cabinets and boxes. Monel mesh gaskets are welded to equipment covers, or aluminum wire screen mesh welded over ventilation holes by the thermobaric process. Before the weld is made, a narrow aluminum retaining strip is placed over the edge of the mesh or screen which is next to the main body.

Mechanical tests have determined that optimum thicknesses are as follows: 0.020 in. for the retaining strip; 0.032 to 0.125 in. for the base material which must have a ½-in. minimum width. The aluminum screen was 18-14 mesh, 0.020-in. dia wire; the monel mesh was 0.004-in. dia mesh with 0.02-in. grid.

Extensive tests have also been made to establish optimum values of current and force, as well as types of electrodes. All thermobaric bonds have met or exceeded the mechanical environmental requirements for aircraft electronic equipment service. Previous to the discovery of this reaction, riveting was used but was not entirely satisfactory due to costs involved and the electrical and water-tightness requirements.

Acknowledgments

The author would like to express his appreciation for the assistance of personnel and literature from the following organizations in preparing this article:

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Budd Co.
Emmco Development Corp.
Frankford Arsenal
General Electric Co.
High Vacuum Equipment Corp.
Linde Co., Div. of Union Carbide Corp.
New Rochelle Tool Co.
NRC Equipment Corp.
Precision Welder and Flexopress Corp.
Ravens-Metal Products, Inc.
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first in silicones

Dow Corning

SILICONE NEWS

for design and development engineers • No. 70

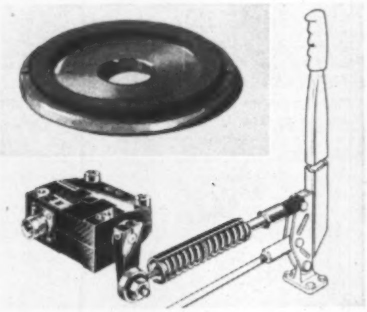
HOW TO ASSURE POSITIVE BRAKING

Problem: Finding a rubbery brake facing that can withstand rugged braking action and high temperatures over extended periods of time.

Solution: Airborne Accessories Corporation, Hillside, N. J., reports excellent results with Silastic®, the Dow Corning silicone rubber. Here's their story:

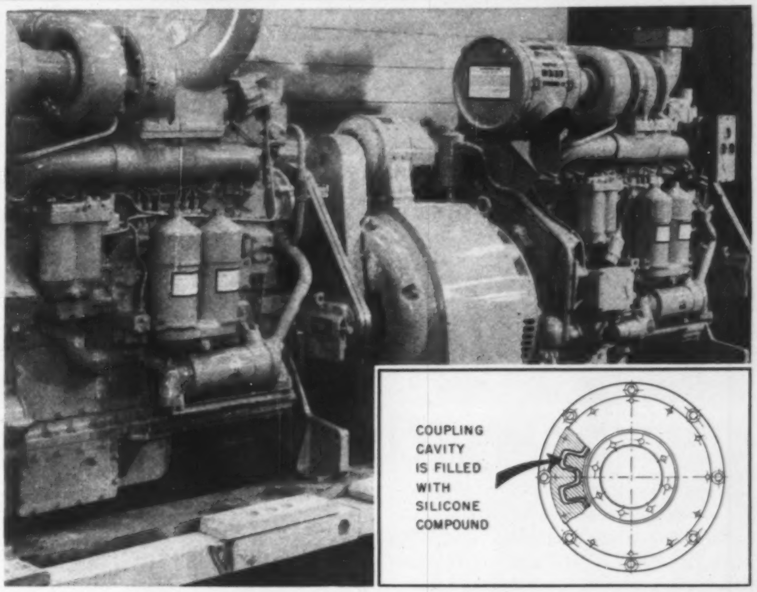
Airborne developed an improved steering control system for rotary wing aircraft. The key unit is a magnetically controlled brake located near the engine that locks the steering controls to relieve the pilot from fatigue. After evaluating various materials, Airborne chose Silastic for the brake facing because its exceptional heat stability, and low compression set characteristics make it the most serviceable and reliable under adverse operating conditions.

The washer-shaped molding of Silastic is 1/16 inch thick and has an outside diameter of 1-13/32 inches. This silicone rubber part enables the braking system to withstand at least 200 inch-pounds of continuous torque at the output shaft (4 inch-pounds at the brake).



Specifications called for a braking surface that would withstand a temperature of 212 F for 48 hours without loss of strength, shape or braking efficiency. Several hundred of these units have been in service for extended periods without a single report of brake facing burnout or other failure.

Because Silastic stays rubbery from —130 to 500 F and is resistant to weathering and many fuels, oils and chemicals, this material is finding growing use for a variety of applications in the aircraft, automotive, and appliance industries. *No. 241*



UNIFORM DAMPING EXTENDS UTILITY

How can you best provide damping in a flexible coupling and reduce the effects of torsionals at critical speeds? Do as the Engine Division of Caterpillar Tractor Co. did: Couple the benefits of a thick rubber cushion with the uniform performance of a greaselike Dow Corning silicone compound.

Caterpillar recently developed a viscous damped, rubber coupling to minimize torsional vibration between engines and any type of loads, or between engines connected in tandem. Heart of the unit is an internal ring gear connected to the engine. This gear meshes with a gear drive spider connected to the load. A thick rubber boot that encloses the internal teeth provides the flexual member.

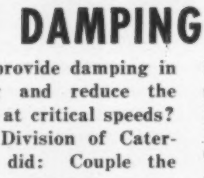
Caterpillar engineers provided effective damping by filling the ⅛ inch void between rubber boot and drive spider teeth with a Dow Corning silicone compound that maintains a near-constant consistency over a very wide temperature range. Damping from the silicone compound effectively reduces torsional vibration amplitudes caused by torque reversals between load and engine at resonant frequencies.

Dow Corning silicone damping media — both greaselike and fluid — provide uniform damping regardless of temperature, resist oxidation — won't evaporate, thicken or thin-out—and resist breakdown due to shear. In the Caterpillar Coupling, the silicone damping medium helps "preserve" the rubber and give it longer life. *No. 242*

Lubricants that Last

Best way to provide long-lasting, troublefree lubrication: Specify a nonoxidizing, nongumming silicone lubricant. That's how Appliance Manufacturing Company, Van Buren, Indiana, assures the accuracy and long service life of its timing devices.

Appliance Manufacturing's engineers have found that it pays to use heat-stable Dow Corning 44 Grease on timers that might encounter rough service conditions. A case in point is the timer illustrated below which is used in a popular automatic dryer.



Experience has shown that a minute quantity of Dow Corning 44 Grease applied to this timer's shaft and phenolic cam is all it takes to (1) reduce friction and obtain proper degree of torque in turning the timer dial,

(Cont. Pg. 2)

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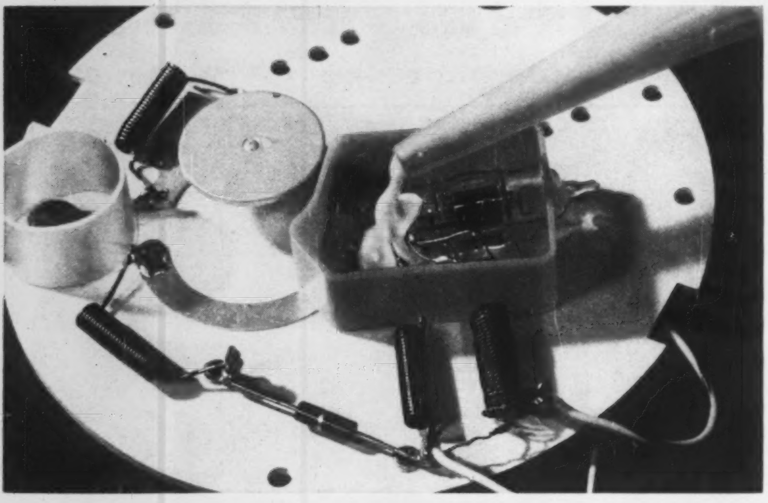

CONFORMS, CUSHIONS, SEALS

Silicones repeatedly enable engineers to design to a fine degree of miniaturization and provide optimum protection against adverse environmental conditions. Such a case is the use of Silastic RTV in the Radio-Sondes manufactured by General Instrument Corporation, Newark, New Jersey.

Radio-Sondes are meteorological instruments linked to integral transmitters. Designed to be launched from aircraft at altitudes up to 60,000 feet and speeds up to 565 knots, these instruments are subject to reduced air pressure and the hazards of arcing and corona due to high potentials involved. At launching, severe slipstream shock and vibration are encountered.

General Instrument engineers specified that vulnerable components of the Radio-Sonde units be encapsulated with Silastic® RTV, the Dow Corning silicone rubber that vulcanizes at room temperature. Sliastic RTV flows around intricate parts during application, sets up to a rubbery cushion that puts no stress on delicate parts, and seals out undesirable elements with no degradation of power factor.

Silastic RTV is easily applied with a calking gun into reusable retainer rings, provides the desired physical and dielectric properties. Heat-stable, and flexible in low temperature service, Silastic RTV remains resilient and soaks up shock.

TYPICAL PROPERTIES OF SILASTIC RTV

Temperature range (—70 to 260 C)	—100 to 500 F
Dielectric strength, volts/mil	400
Dielectric constant, 10^6 cycles per second	3.0
Dissipation factor, 10^6 cycles per second	0.004
Moisture absorption after 7 days at room temperature	<1.0%

The preceding table of properties may provide an indication of the practicality of Silastic RTV as an engineering material in your electrical or electronic equipment. For more information, circle . *No. 243*

LUBRICANTS *(Continued)*

(2) make certain of long service despite moisture and heat and (3) avoid injurious vapors that might poison the silver contacts.

You can count on Dow Corning silicone oils and greases to remain effective long after the best organic lubricants have melted, gummed or oxidized. Job-proved Dow Corning 44 Grease, for example, is serviceable from —40 up to 400 F, provides exceptionally long "shelf life", keeps warranty costs low, and assures quiet operation. *No. 244*

new literature and technical data on silicones

Seal That Valve even under conditions of extreme temperature and contact with acids, alkalies, or steam. Dow Corning Valve Seal retains its uniform consistency . . . keeps pressure-lubricated valves operable. Also lubricates, protects and extends life of most rubber and plastic seals, gaskets and packings. Job-proved in more than 100 different applications listed in this comprehensive data sheet. *No. 245*

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You say, they save — You can provide up to 100% longer surface protection if you specify silicone-based paints for the domestic appliances and the industrial equipment you design. Examples of design-customer savings are illustrated in a 4-page brochure. A unique, full page nomograph will help you choose the type of paint best suited for every application, and a separate listing of producers of silicone paints is also included to assist you in obtaining the protective coating you seek. *No. 246*

•

SILICONE
INSULATING
COMPONENTS

An Up-to-Date Selection Guide helps you choose the silicone insulating components that make possible electrical equipment with 10 to 100 times longer life. This complete selection table for silicone insulating components and listing of distributors make this brochure an absolute must for every electrical designer's reference files. *No. 247*

•

How To Make Coils more easily . . . and also get better performance . . . is the subject of a compact 8-page booklet reprinted from NISA News. The use of triangular Guideline Tape facilitates and speeds wrapping — provides the good electrical properties, thermal stability, chemical and moisture resistance characteristic of Silastic®, the Dow Corning silicone rubber. This reprint contains helpful graphs, tables, and illustrations. *No. 248*

•

You And The Silicones — a new 30-minute, full color movie lets you see silicones in action. It's an all-encompassing, dramatic documentation of designers' adaptations of these versatile engineering materials in different applications. For information about arranging for a free showing, request *No. 249*

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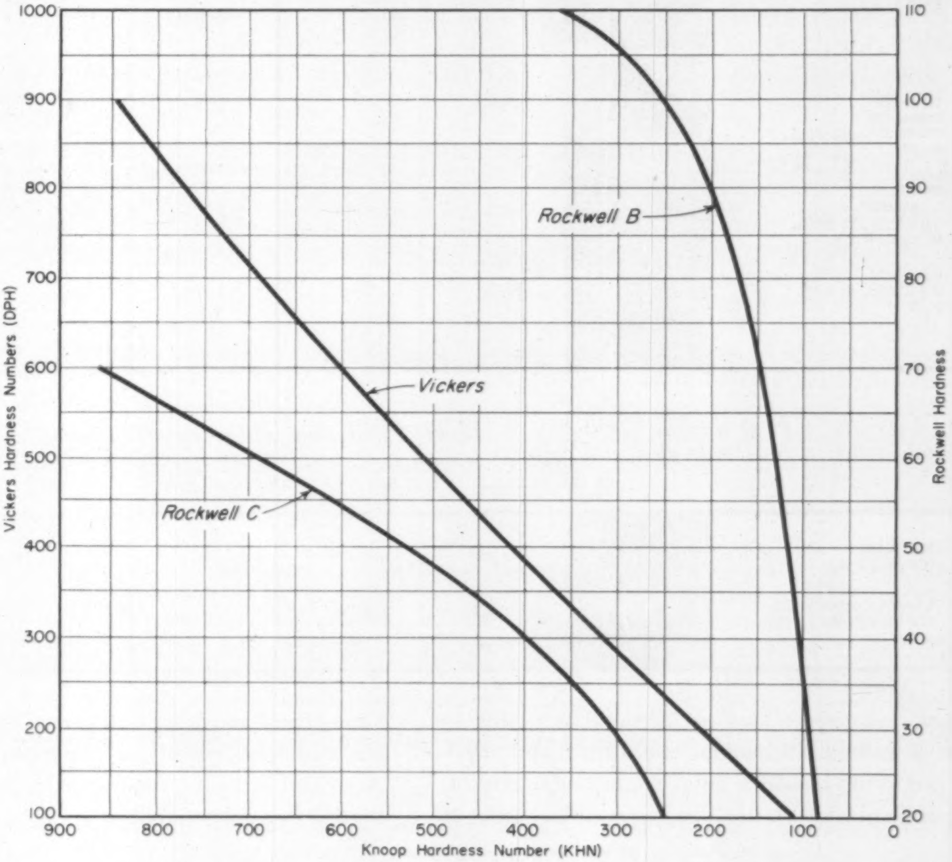
FILE FACTS

Conversion Chart for Microhardness Values



This graph can be used to convert microhardness values to the more commonly used macrohardness scales. Simply read up from the Knoop scale to the Rockwell B or C curve or the Vickers curve, and from that intersection over to the appropriate ordinate scale. Although the reverse conversion can also be made, the values obtained would be meaningless. The Knoop and Vickers testers can be used to determine hardness of a single grain of metal, the Rockwell testers only to determine hardness of relatively large areas.

Courtesy R. A. Slepian, Materials Engineering Dept., Westinghouse Electric Corp.

QUICK COMPARISON CHART

Some unique combinations of electrical and physical properties in Anaconda metals that may save you money—handle tough jobs better

Properties shown for precipitation-hardened condition—Heat-treatable alloys	ELECTRICAL CONDUCTIVITY % IACS	TENSILE STRENGTH psi	YIELD STRENGTH at 50% ext. under load, psi	ELONGATION % in 2 in. or 4xD	MACHINABILITY compared with F.C. Brass at 100	FORMS AVAILABLE
Chromium Copper-999 (Cu 99.05%, Cr .85%, Si .10%)	75	65,000	55,000	20	20	Rod Wire Tube Forgings Strip
Leaded Nickel Copper-831 (Cu 97.8%, Pb 1.0%, Ni 1.0%, P .2%)	55	80,000	70,000	7	80	Rod
Cunisil-837 (Cu 97.5%, Ni 1.9% Si .6%)	30 to 42	90,000	70,000	8	40	Rod

To give you a basis of comparison, here are properties of two standard Anaconda electrical coppers

ETP Copper—100 (Cu 99.9+%)	100	48,000	40,000	15	20	All mill forms
Leaded Copper—126 (Cu 99.0%, Pb 1.0%)	98	48,000	40,000	12	80	Rod bar

The values given above are intended as a guide to some unusual combinations of electrical and physical properties available among Anaconda alloys. If any of them gives you an idea for possible solution to a tough problem or indicates a way to cut costs without sacrificing quality or performance — see your American Brass representative for more details. Or send in this coupon today.

5949

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☐ Leaded Nickel Copper—831
☐ Cunisil—837
☐ Leaded Coppers
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MATERIALS AT WORK

...AT A GLANCE

Aluminum wheels with integral hub and brake drum are now available as optional equipment on 1960 Pontiacs. The aluminum wheels, originally developed in 1957, offer these advantages: superior brake performance, greater strength, and lighter weight. Another outstanding advantage is a significant reduction in brake fade as a result of the rapid heat dissipation provided by aluminum's high thermal conductivity.

Source: Kaiser Aluminum & Chemical Corp.; wheels fabricated by Kelsey Hayes Co.; used by Pontiac Motor Div., General Motors Corp.

A vinyl coating applied to the TV antenna atop the Empire State Building has passed the half-way mark in its expected service life. Applied in 1950, the coating was specified to last through 1965. Thus far, only a minor touch-up has been necessary. The coating system applied to the galvanized metal consists of four metal primer coats of red lead and two coats of aluminum-pigmented vinyl.

Source: Union Carbide Plastics Co., Div. of Union Carbide Corp.; coating manufactured by Sapolin Paints, Inc.

A switch from stainless to tungsten carbide has resulted in a 90% reduction in the cost of spray nozzles used to apply a lid sealing material on metal can-making machines. Actually, the carbide nozzles cost $7.22 apiece, as compared to only $3.00 for the stainless nozzles. However, they last more than 20 times longer—an increase from 540 hr max for stainless to over 13,000 hr for the carbide nozzles. Another advantage: a pressure increase from 55 to 100 psi.

Source: Kennametal, Inc.,

When, and if, the electric car returns, sintered plate, nickel-cadmium batteries are expected to play an important role in the power plant. One possible way to extend the range of the power plant (batteries need recharging after 100 miles) is the use of a generator, driven by a one or two-cylinder gasoline engine, to constantly recharge the battery during operation.

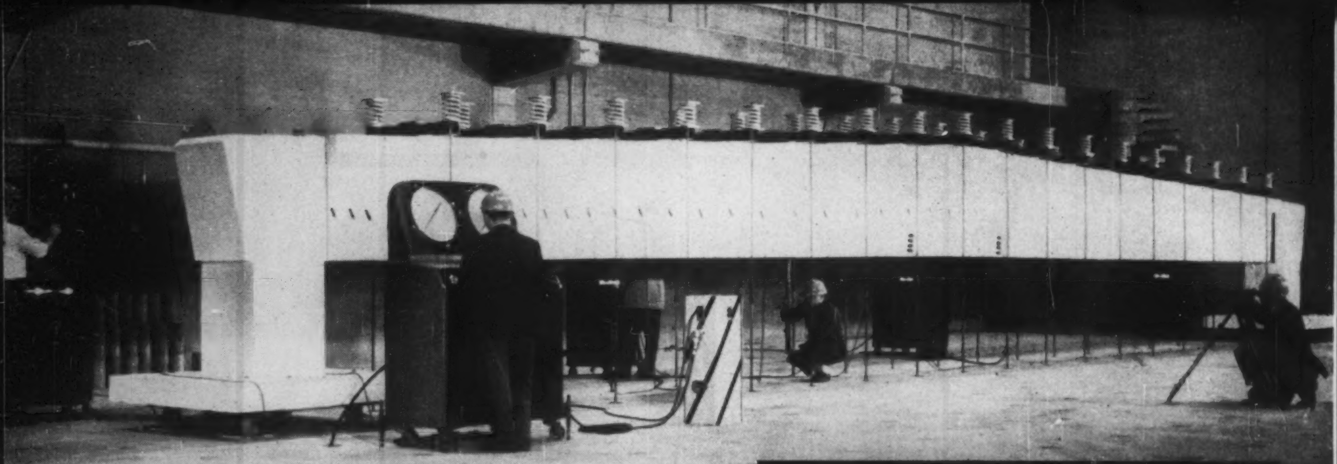
Source: International Nickel Co.; batteries manufactured by Sonotone Corp.; research conducted by American Motors Corp.

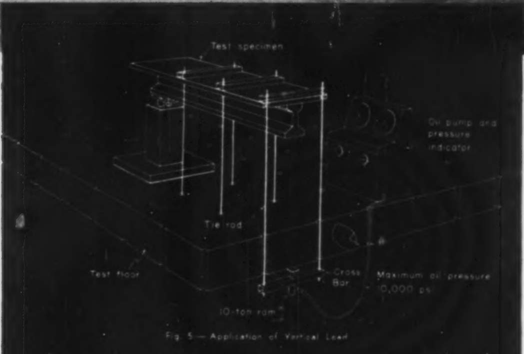
Acrylic fiber is now being used for weatherstripping in new aluminum storm windows. Because of its low moisture absorption (about 1% as compared to 16% for wool) and its superior resiliency, the new weatherstripping is expected to outlast conventional materials by as much as 50%. In addition, the acrylic weatherstripping 1) does not freeze, 2) is mildew-proof, 3) is non-allergenic and 4) does not mat during damp weather.

Source: Chemstrand Corp.; weatherstripping manufactured by Kessler Products, Inc.; used by Air Master Corp.

Improved physical properties, elimination of weldments and lower cost are the advantages claimed for what is said to be the largest zirconium extrusion ever made—a 51½-ft long tube used in nuclear power reactors. The tubing, which has a 3.48-in. o.d. and a 0.360-in. wall, replaces tubing previously made by welding three smaller extrusions. Zirconium alloy tubing is specified for reactors because it offers a low-neutron-absorption cross section and excellent corrosion resistance.

Source: Harvey Aluminum.

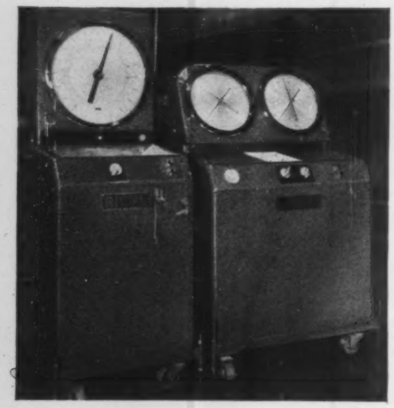



Test specimen
Oil pump and pressure indicator
Tie rod
Test floor
Cross Bar
Maximum oil pressure 10,000 psi
10-ton ram
Fig. 5 — Application of Vertical Load

Custom designed concrete testing machine at Portland Cement Association's Research and Development Laboratories, Skokie, Illinois. Diagram shows hydraulic mechanics.

This laboratory is a giant testing machine in itself

Designed to accommodate a wide range of concrete specimens, from small beams to large structural assemblies, this hydraulic testing machine utilizes the building floor as an integral part. 690 holes in the floor permit versatile arrangements of tie rods which connect load applicator bars to a series of 10-ton rams below floor level.



From below the floor . . . load delivered by RIEHLE units

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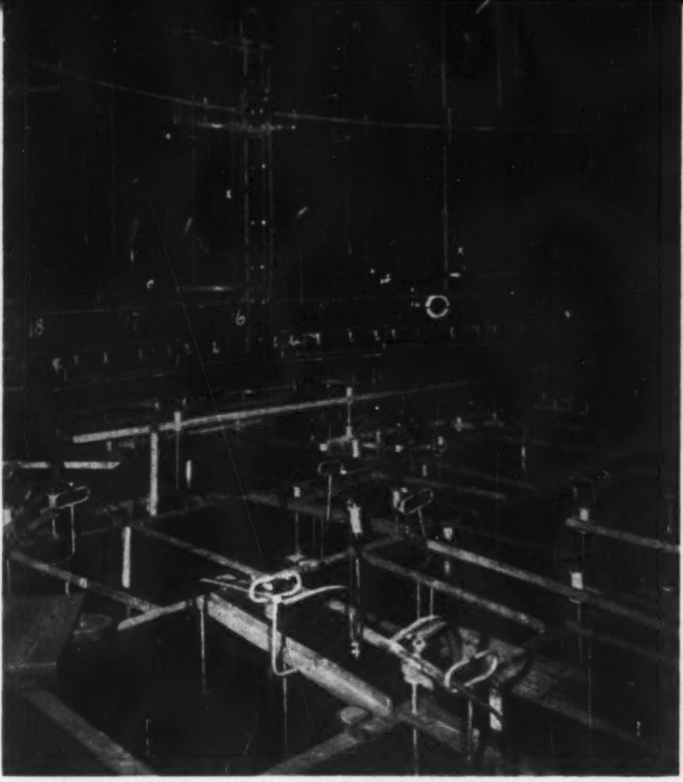


Radiant heater *network raises vessel temperature to 1200 F.*

Glass fiber insulation *keeps heat losses down.*

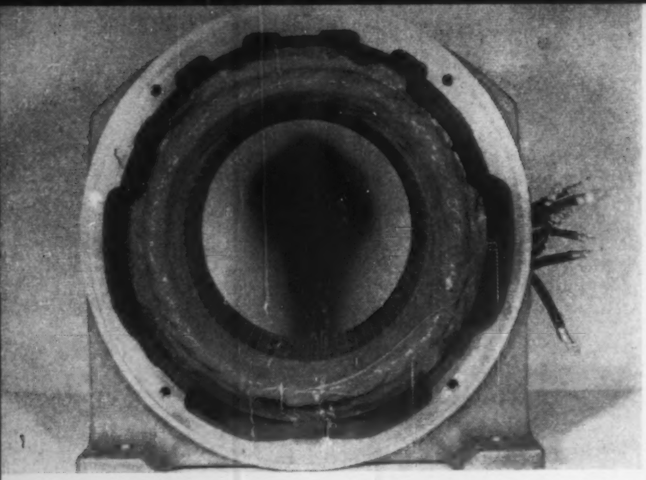
A two-week heat treatment:

World's Largest Reactor Stress Relieved on Site

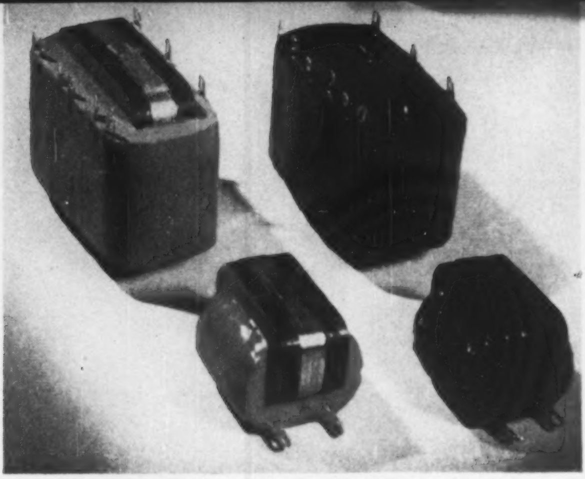
■ A nuclear reactor vessel, 80 ft high by 50 ft in dia and made up of 3 to 4-in. mild steel plates, has been successfully stress relieved in the field by John Thompson Ltd., Wolverhampton, England. The on-site heat treatment was necessary to relieve all stresses set up in the vessel during final welding and fabrication.

Heat was applied from a 2-megawatt source of electricity through a network of busbars and sheathed radiant heaters inside the vessel (see photos). Two days were required to bring the vessel up to the 1070-1200 F stress relief temperature. After a suitable soaking period the vessel was slowly cooled over a period of two weeks. Heat losses were kept to a minimum by insulating all external surfaces of the vessel with a glass fiber lagging.

A large number of instruments installed in the vessel provided engineers with a close check on changes of shape of the vessel during heat treatment. In addition, temperatures were checked with over 300 thermocouples connected to a central control room from which temperatures could be carefully regulated.



1—*Encapsulated stator windings.*



2—*Encapsulated transformer coils.*

Silicone Rubbers That Cure at Room Temperature

Here is a quick look at some current uses.

by **C. A. Berridge and R. Treat, Jr.,** *Rubber Specialists, Silicone Products Dept., General Electric Co.*

■ Although not as strong as heat-cured silicone rubbers at room temperature, RTV (room temperature vulcanizing) silicone rubbers have excellent heat resistance and negligible (0.2%) linear shrinkage during cure.

Table 1 shows typical properties of four RTV compounds (three liquids, one paste), compared with properties of two typical heat-cured silicones—a low compression set and a high strength compound. Table 2 shows effects of heat on the RTV materials.

RTV compounds are moderate in price, i.e., about $3.85 per lb compared with $2.30-4.90 per lb for heat-curing silicone rubbers. Cure times may range from as short as 10 min to as long as three to six days, depending on type and amount of the metallic soap curing agents used. Heat, of course, speeds the cure.

Like most silicones, RTV compounds exhibit generally good mold release characteristics. On the other hand, excellent adhesion is also obtainable when surfaces are properly primed.

The RTV compounds complement—do not replace—their heat-cured counterparts. They usually do not provide any benefits in applications for which oven-cured silicone rubbers are feasible and economical.

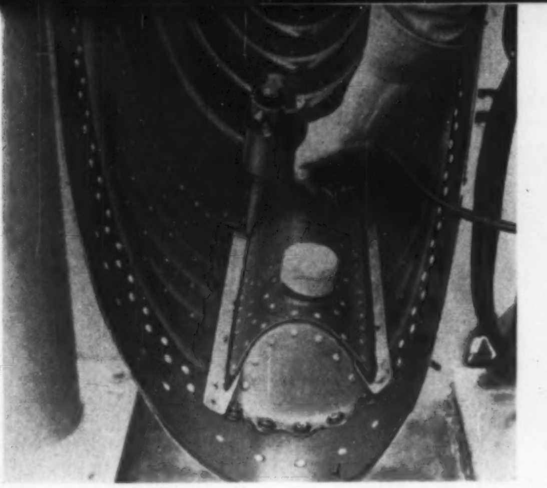
Electrical uses

Room temperature cure and low shrinkage can be extremely advantageous in electrical potting and encapsulation. Also, RTV compounds provide the same good electrical insulating characteristics and resistance to extremes of temperature as heat-cured silicone rubbers.

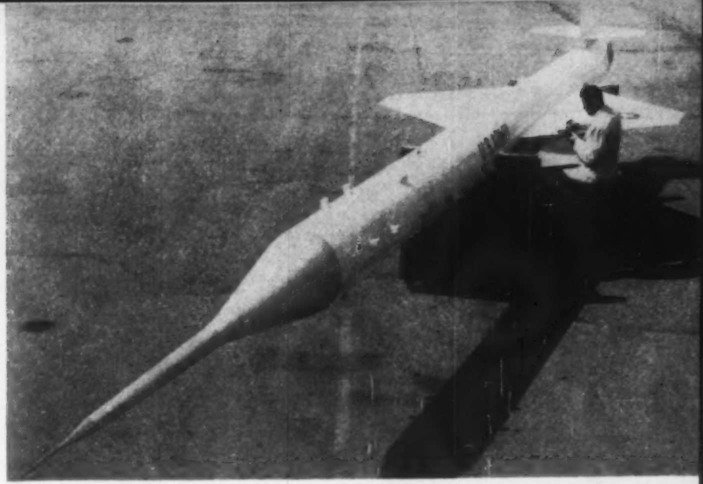
A new line of drip-proof motors developed by GE uses RTV to encapsulate the stator windings, as shown in Fig 1. An elastomeric encapsulant was needed to seal, protect and insulate, as well as cushion the windings from vibration. An RTV silicone elastomer was selected because of its low viscosity, room temperature curing characteristics, and handling flexibility. It also provides the required heat resistance, low shrinkage, and inertness to ozone, oils and other chemicals. RTV permits use of the drip-proof motor in certain severe environments that had previously required totally enclosed motor construction.

Two RTV compounds are used to encapsulate aircraft transformer coils manufactured by Hughes Aircraft Co. Fig 2 shows the coils at two stages of production. In the first stage, coils are impregnated with a low viscosity RTV compound; in the second stage they are encapsulated with a tougher RTV compound to serve as an external protective coating.

Hughes found that RTV was the only material which met all requirements. The coils are designed to operate at 480 F and must meet requirements of MIL-T-27A. Other varnishes and rubbers were found inadequate for several reasons: 1) they were unable to operate at the required high temperature; 2) they were unable to completely impregnate tightly wound coils,

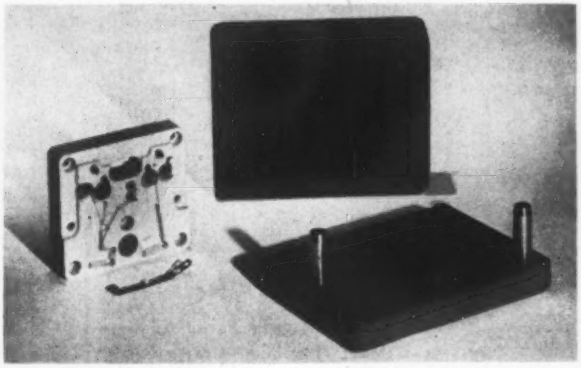


3—*Hot duct sealing of DC-8.*

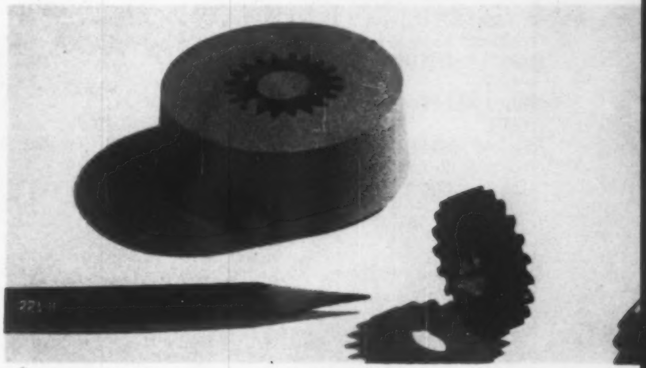


4—*Sealed fuselage of Kingfisher target missile.*

AIRCRAFT SEALING



5—*Mold for cast epoxy fixture.*



6—*Mold for cast epoxy helix gear.*

LOW COST FLEXIBLE TOOLING

and 3) when solvent systems were used, solvents degraded the insulation and, when removed, left voids.

RTV can also be used as a coating on cloth for electrical insulation. The low temperature curing characteristics permit efficient coating of heat-sensitive fabrics.

Aircraft sealing

A survey of the aircraft industry revealed the need for a sealant which would retain adhesion and some flexibility with no cracking or blistering during 500 hr at 400 F, 168 hr at 500 F, and 40 hr at 600 F. Such a sealant had to cure at room temperature, among other requirements listed.

RTV meets or exceeds all the requirements listed. It is now widely used for high temperature sealing of such components as cabins and cockpits, fire walls, fuel tanks and hot air ducts. Fig 3 shows RTV being used to seal an integral hot air duct on the leading edge wing section of the Douglas DC-8 jet airliner.

A saving of $1600 per missile resulted from Lockheed Missile Systems Div.'s use of RTV silicone rubber to seal the fuselage of its recoverable Army target missile, "Kingfisher," shown in Fig 4. In flight, the missile attains skin temperatures of about 300-700 F, and must maintain internal hull pressures of about 25 psi. Consequently, the entire fuselage must be sealed.

Originally, a special high temperature organic coating was developed. It was found unsatisfactory on two counts: 1) difficulty in applying the coating and a long 5-day cure time resulted in a total sealing cost of about $2000 per missile, and 2) excessive hull leakage at operating temperatures resulted in unsatisfactory performance.

The RTV sealant, which cures in 24 hr, operates satisfactorily in service. Total sealing cost is $370 per missile.

Flexible short-run molds

In addition to curing at room temperature and having negligible shrinkage, RTV compounds combine the accuracy of rigid mold materials with the ease of handling of conventional flexible mold materials.

The bulk of the work done with RTV as a flexible mold material has been carried out with cast epoxy resins. RTV molds withstand the exothermic heat generated during the cure of epoxy casting resins, and require no parting agent treatment prior to casting the epoxy. Information on

TABLE 1—PROPERTY COMPARISON: RTV vs HEAT-CURED SILICONE RUBBERS

Type ➡ Durometer Hardness (Shore, D676) ➡	RTV Liquids A50[a]	RTV Liquids A55[b]	RTV Liquids A60[c]	RTV Paste A60[d]	Heat Cured Silicone Rubbers A60[e]	Heat Cured Silicone Rubbers A50[f]
FABRICATING PROPERTIES						
Consistency	Easily poured	Pourable	Pourable	Stiff paste	Millable gum	Millable gum
Viscosity, poise	300	450	550	12,000	—	—
Typical Cure Time (firm), hr						
Silicure L-24[g]	24-48	24-48	48-72	24-48	Heat cured[e]	Heat cured[f]
Thermolite-12[h]	16-24	8-12	16-24	1-4	Heat cured[e]	Heat cured[f]
Linear Shrinkage, %	0.2	0.2	0.2	0.2	1.9	3.5
PHYSICAL PROPERTIES						
Specific Gravity	1.30	1.37	1.45	1.45	1.19	1.18
Ten Str (D412), psi	450	550	650	750	1000	1550
Elong (D412), %	140	120	110	160	120	650
Tear Str (D624, die B), lb/in.	25	25	50	50	65	200
Peel Str (D429), lb/in.[h]	—	4.0	4.5[i]	6.5[i]	—	—
ELECTRICAL PROPERTIES[j]						
Vol Res (D257), 10^{13} ohm-cm	1,5		1,5		10	1000
Dielectric Str (D149), v/mil	500		500		450	550
Dielec Const (D150, 60 cps)	4.0		4.0		4.5	3.0
Power Factor (D150, 60 cps), %	1-2		1-2		4.0	0.1
CHEMICAL RESISTANCE[k] (D471)						
ASTM No. 1 Oil (70 hr, 300 F)						
Hard. Chg, Shore A units	−15		−5	−10	−5	−5
Ten Str Chg, %	−30		−10	−35	−5	−40
Elong Chg, %	0		0	−30	0	−35
Weight Chg, %	+2.5		+2.0	+1.2	+5	—
Vol Chg, %	+5.1		+3.8	+3.0	+8	+12
Skydrol 500 (70 hr, 80 F)						
Hard. Chg, Shore A units	−4		−3	−5	−5	—
Ten Str Chg, %	−10		−5	−15	−22	—
Elong Chg, %	0		−30	−20	0	—
Weight Chg, %	2.9		+2.1	+2.8	—	—
Vol Chg, %	3.6		+3.0	+4.2	+5	—
5% NaCl–Dist Water (70 hr, 80 F)						
Hard. Chg, Shore A units	0		−5	−5	—	—
Ten Str Chg, %	0		0	−5	—	—
Elong Chg, %	0		0	−20	—	—
Weight Chg, %	0		+1	+1.0	—	—
Vol Chg, %	0		+1	+2.2	—	—
JP-4 Jet Fuel (70 hr, 80 F)						
Hard. Chg, Shore A units	—		−7	−15	−7	—
Ten Str Chg, %	—		−25	−50	−39	—
Elong Chg, %	—		−65	−45	−50	—
Weight Chg, %	—		+55	+80	—	—
Vol Chg, %	—		+110	+180	+150	—

[a] RTV-20. [b] RTV-40. [c] RTV-60. [d] RTV-90.
[e] SE-362: typical low compression set compound; cured 24 hr at 450 F.
[f] SE-555: typical high strength compound; cured 3 hr at 400 F.
[g] Nuodex Products Co.; Silicure T-773 can provide 30-min cure for the A55 durometer stock.
[h] Bonded to primed 18-8 stainless steel. [i] Rubber failed.
[j] RTV tests made at 77 F, 50% RH on 0.08-in. ASTM slabs cured 72 hr at 80 F.
[k] RTV compounds: cold pressed ASTM sheets cured with 1% Silicure L24 for 144 hr at 80 F.

TABLE 2—HOW HEAT AGING AFFECTS RTV SILICONE RUBBERS[a]

Hardness (orig, Shore) ➡	Pourable Liquids A50[b]	Pourable Liquids A55[c]	Pourable Liquids A60[d]	Paste A60[e]
24 HR AT 400 F				
Hard. Chg, Shore A units	+5[f]	+3	0[f]	0
Ten Str Chg, %	0[f]	0	0[f]	0
Elong Chg, %	0[f]	0	0[f]	0
Tear Str Chg (die B), %	0[f]	0	0[f]	0
70 HR AT 400 F				
Hard. Chg, Shore A units	+10	+3	0	0
Ten Str Chg, %	0	0	0	0
Elong Chg, %	−10	0	0	0
Tear Str Chg (die B), %	0	0	—	−10
40 HR AT 600 F				
Hard. Chg, Shore A units	Embrittles	—	+15	+15
Ten Str Chg, %	—	—	−8	−10
Elong Chg, %	—	—	−40	−50
Tear Str Chg (die B), %	—	—	−20	−30

[a] Tests made at room temperature. [b] RTV-20. [c] RTV-40. [d] RTV-60. [e] RTV-90. [f] 24 hr at 480 F.

Editor's Note

Since the preparation of this article, the following new developments in RTV silicone rubber have been announced:

1. One-component RTV compounds which cure on exposure to air are available in experimental quantities from Dow Corning Corp. Primary uses appear to be as sealants; they do not seem promising for electrical uses.
2. A one-component RTV fluoro-silicone rubber is reportedly in development stages at Dow Corning Corp.

compatibility of RTV with other types of resins, such as polyesters and polyurethanes, is limited. Developmental work indicates that no problems should be encountered with such materials.

The complex, cast-epoxy conveyorized fixture shown with its two-part RTV mold in Fig 5 is designed to assemble motor switch components on an automatic machine. Originally machined from an industrial thermosetting laminate, the part required jig-bored holes for locating pins which had to be held to a tolerance of ±0.002 in. Sixty machined fixtures cost $175 each.

The two-piece RTV mold which was cast from a master, costs less than $50, and the parts cast, complete with pin inserts, costs $10 each—a saving of more than $150 per part.

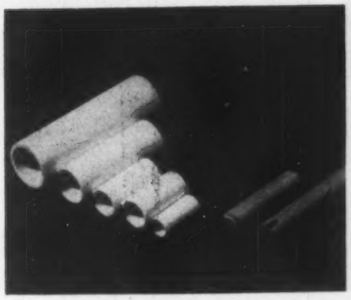
The low cost, two-part cast RTV mold shown in Fig 6 is used to cast close tolerance, nonstandard helix gears in epoxy resin. Originally these gears, replacement parts on original equipment, were machined from a plastics laminate. Although no draft or clearances exist on any part of the helix gear, close tolerance epoxy replacement gears can be easily produced in the flexible mold.

Ceramics Provide Cleanability, Color, Controlled Porosity

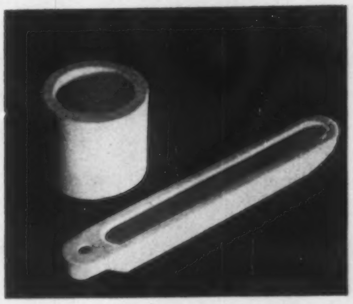
plus heat resistance, electrical insulation

■ In addition to high temperature and electrical applications, ceramics are being used increasingly where such special properties as controlled porosity, cleanability and color are needed. The photos show six examples of how these properties are used to advantage in ceramic parts manufactured by Saxonburg Ceramics, Inc.

Other trends to keep in mind: ceramics are now obtainable with very high chemical purity and in very small sizes. For example, new high purity alumina contains as little as 8 ppm of undesirable elements, and zirconia is available with a hafnium content of less than 0.008% and with as little as 5 to 8 ppm of cadmium or boron. Thermocouple tubes with a 30-mil o.d. and containing two 6-mil holes are now available, and walls as thin as 10 mils have been produced on other tubular forms.

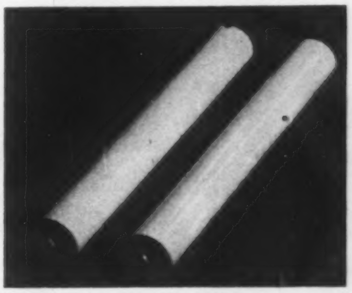


Electrical insulation *properties of ceramics are used to advantage for these capacitor sleeves and resistor cores. Parts are made of L3 grade steatite with a loss factor of less than 0.16. Depending on mechanical, thermal and chemical properties needed, electrical components can also be made of other steatites, forsterites, cordierite, aluminum silicate, periclase and refractory ceramics.*

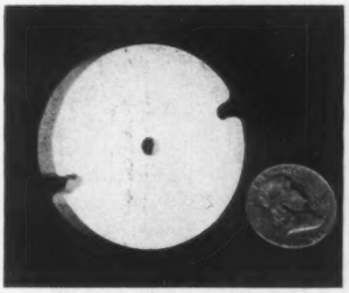


Resistance to thermal shock *is an outstanding property of ceramics; parts can be made to withstand a 45-sec temperature rise of more than 3100 °F. Chemical crucible and boat shown here withstand rapid temperature change up to 3500 F, and resist penetration by stainless or silicon steel slags.*

Heat resistance *is prime requisite for these stabilized zirconia pouring nozzles which must withstand 4200 F without softening. Refractory alumina and zirconium silicate can be used for somewhat lower temperatures—3000 to 3200 F.*



Cleanable, smooth surface *along with ability to withstand combustion are the reasons ceramic was chosen for these keyhole ignition tubes used in oil fired heaters. The ceramic is coated with a glass-like clear glaze that wipes clean easily.*

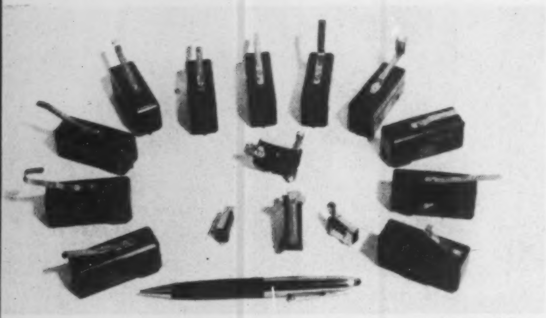


Controlled porosity *was the key factor in selecting a ceramic for this deodorant disk. Porosity is regulated (in this case to 10-15%) so as to absorb a calculated amount of deodorant and release it at a known rate of evaporation.*

Permanently colored *surface can be readily produced on some ceramics to change their basic white, grayish white or tan appearance. Colors not only improve looks but permit color coding and rapid visual identification.*

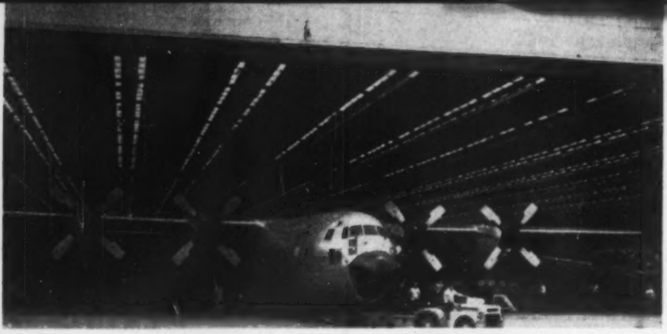
Allegheny Ludlum Steel Corp.

Fuel container *for solid fuel rockets is a possible application for AM-355 if stress analysis results are satisfactory. High strength-weight ratio is deciding factor here.*



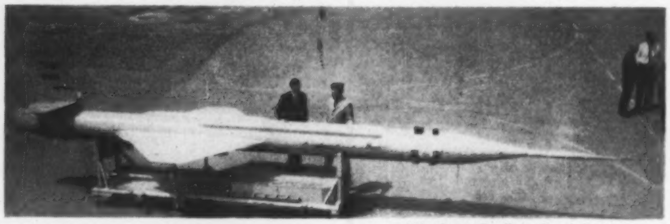
Armco Steel Corp.

Micro switch interior springs *take advantage of fact that 17-7 PH hard drawn wire is an excellent spring material. When hardened, alloy exhibits elastic properties like those of the best music wire and alloy spring steels. In this case 17-7 PH replaced a nonferrous alloy that failed after several million reversals. The new springs withstand over 100 million reversals.*



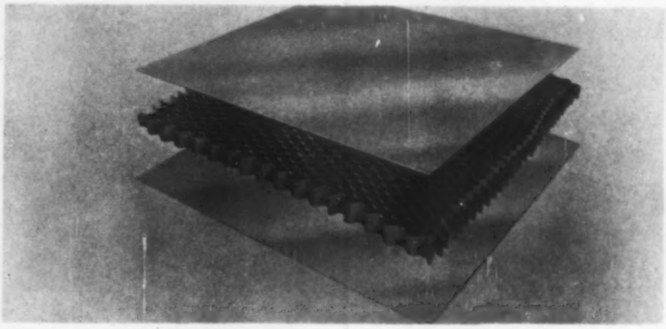
Allegheny Ludlum Steel Corp.

Wing-web sections *of Lockheed's C-130B Hercules are fabricated from 0.50-gage AM-350. Requirements for these sections, which strengthen the wings, are: light weight, strength, stiffness, and a high degree of flatness after heat treatment.*



Allegheny Ludlum Steel Corp.

Fuel tank and camera pod *of the X-7 missile are made of AM-350. The high strength-weight ratio of the alloy allowed the skin thickness to be cut from 1/16 to 1/32 in., effecting a 50% weight saving. Other advantages: good fatigue properties, high corrosion resistance and ease of fabrication.*



Armco Steel Corp.

Honeycomb core *is made of 17-7 PH strip or foil which may range from 0.0010 to 0.0015 in. thick. 17-7 PH is easily formed in the austenitic annealed condition and can be hardened to high strength levels by simple heat treatments which result in a minimum of distortion.*

Seven Uses of Precipitation Hardenable Stainless Steels

They are strong, easily fabricated

■ Until a few years ago, the combination of high strength and corrosion resistance in chromium-nickel stainless steels could be produced only by cold working. However, development of a series of grades that can be hardened by a simple heat treatment has extended applications considerably.

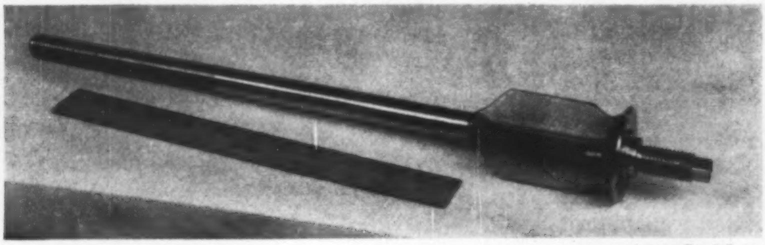
The four alloys used in the products shown here are:

17-4 PH. As annealed, this al-

STRIKE
WITH WELDING
DON'T ST
WITH

Armco Steel Corp.

Control rod position indicators *are fabricated from 17-4 PH. There are 32 indicators on the sides of the trellis of this reactor at the Shippingport atomic-electric generating station. 17-4 PH was chosen because of its good mechanical properties and good weldability without preheating.*



Armco Steel Corp.

Propane gas valve stem *relies on 17-4 PH for high hardness and impact strength, as well as good corrosion resistance. Stem was drop forged, solution annealed and machined with ease. The low temperature heat treatment prevented distortion beyond tolerances.*

loy lacks the formability of the others, but it can be hardened by a single heat treatment. It is outstanding in its ability to withstand welding operations without heat treatment.

17-7 PH. This alloy has good ductility as annealed and is readily formable. It permits low temperature hardening and provides excellent fatigue properties. Hard drawn wire of this alloy is an excellent spring material.

AM-350. Having properties similar to those of 17-7 PH, this alloy was developed primarily for use in aircraft applications. Its composition includes 2.75% molybdenum which adds to its excellent corrosion resistance.

AM-355. The most recently developed of the four alloys, AM-355 provides a well-balanced combination of strength, toughness, ductility and corrosion resistance.

No. 9 of a series

Eastman 910 Adhesive solves another production bottleneck

The Rhine Craft Corporation, of Brooklyn, N. Y., introduced recently a line of costume watch jewelry...pendants, pinfarbs and bracelets.

Key to low manufacturing costs was a fast, simple method of mounting the watch case to the jewelry base. Soldering proved too slow and costly.

The answer was found in quick-setting, high-strength Eastman 910 Adhesive.

The adhesive is applied to the jewelry base and the watch case is set in place. *Within minutes, a permanent bond is formed.* The bond is so strong the gold-plating separates from the watch case when it is forced out of the jewelry base.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

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Bonds Almost Instantly
...Without Heat,
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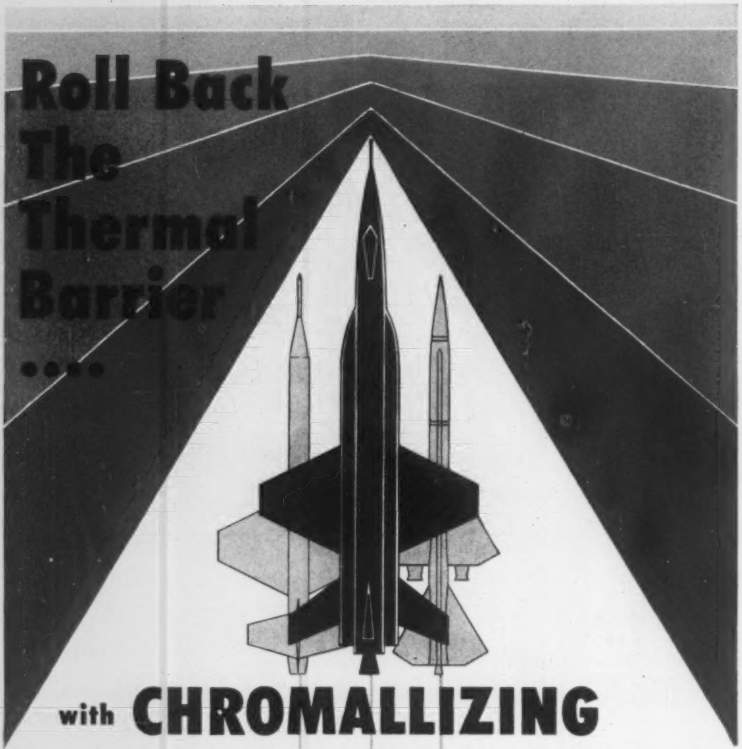
For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9101 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. E-1, Kingsport, Tenn. (Not for drug use)

For more information, circle No. 360



Oxidation and thermal shock resistance of metals used in jet engines and similar superheat applications are greatly improved with CHROMALLIZING. The patented and proven process of diffusing chromium with other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake; the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

Alloy	Usual Operating Temperature	Operating Temperature of CHROMALLIZED Alloy
Iron Base (including stainless steels)	1500° F	SA CHROMALLIZED 310 and 321 stainless steels show no failure after 18 hours at 1950° F in an atmosphere containing lead bromide and lead sulfide.
Nickel Base	1800° F	U CHROMALLIZED nickel base alloys are unattacked after 200 hours at 2000° F.
Cobalt Base	1800° F	SAC CHROMALLIZED cobalt base alloys are unattacked after 150 hours at 2200° F.
Molybdenum	Over 2000° F	W-2 CHROMALLIZED molybdenum shows no failure after 400 hours at 2350° F, after 48 minutes at 2800° F, and after one minute at 3400° F.

Ordinary steel can also be chromallized to provide resistance to corrosion, oxidation and wear.

A recent Chromalloy development, IOCHROME (99.997 % pure chromium), is a basis for chromium alloys for use at 2500°F.

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MATERIALS AT WORK

Intermetallic Devices Operate at 600 F

Point contact rectifiers now being made of gallium arsenide are said to be capable of operating at temperatures up to 600 F.

The rectifiers, developed by Bell Telephone Laboratories, are expected to find use in many diode applications because gallium arsenide is insensitive to changes in operating temperatures. High speed switching diodes have already been made which show no carrier storage effects for switching times up to 10^{-10} sec.

The material is formed by combining an element in Group III of the periodic table of elements with an element of Group V. The resultant intermetallic compound is said to have the "better properties" of silicon and germanium, two Group IV elements now in wide use in semiconducting devices.

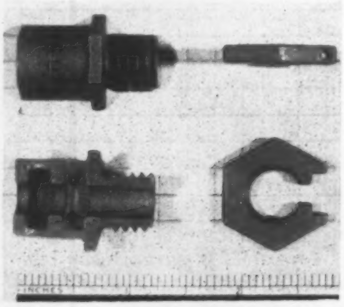
Investment Cast Seal Replaces Machined Part

An investment cast stainless steel bushing has solved a difficult problem in the design of a cable seal in aircraft engines.

According to Lockheed Aircraft Corp., the original plan called for the part to be machined. However, because of the seal's intricate design, it turned out to be less expensive as an investment casting.

Rigid specifications

Specifications for the seal, which is positioned between the cable and

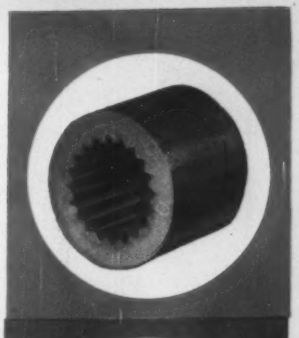


Cable seal *consists of investment cast bushing halves, washers (not shown) and slotted nuts.*

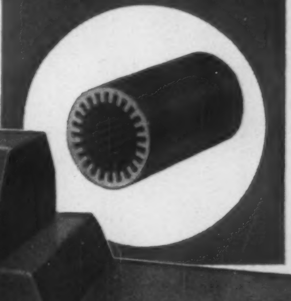
For more information, circle No. 373 ➤

Another Meta-Dynamics Division development in

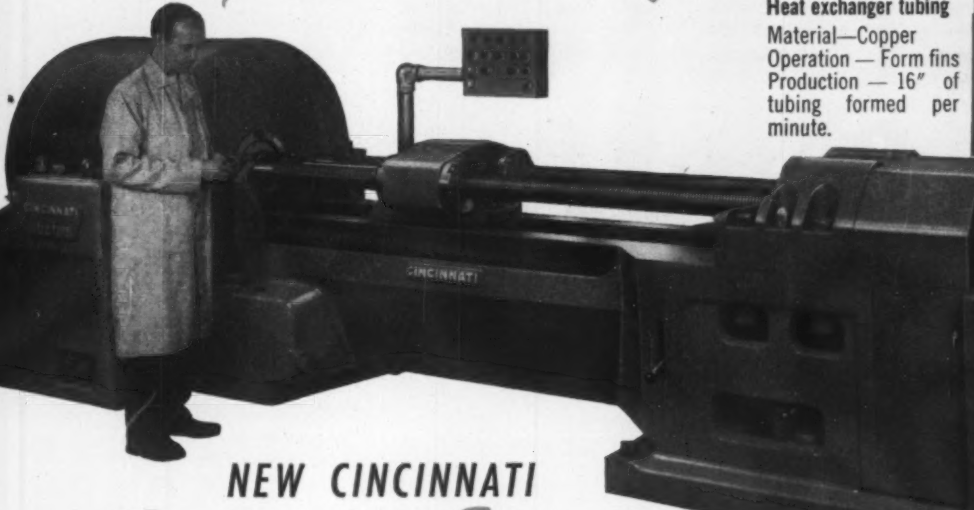
"Chipless machining"!



Ratchet
Material—AISI C-1020
Operation—Form I.D.
Production—300/hr.



Heat exchanger tubing
Material—Copper
Operation — Form fins
Production — 16″ of tubing formed per minute.



NEW CINCINNATI

Intraform

Rapidly produces complex internal profiles to close tolerances, with low cost tooling.

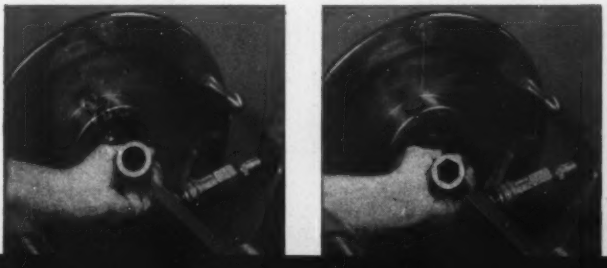
This new *chipless machining* method makes possible low cost production of parts having intricate I.D. profiles that would be difficult or time consuming to machine by conventional methods.

Hollow cylindrical stock, ferrous or non-ferrous, with open or blind holes, is placed over a mandrel and "kneaded" by rapidly pulsating, rotating dies. The smooth, continuous kneading action redistributes the metal to reproduce the profile of the mandrel in the I.D. of the part. The work is formed to close tolerances and with fine surface finish. Tensile strength and hardness of the metal are also improved.

Work diameters ranging from ⅛″ to 5″ can be cold formed on standard Cincinnati Intraform machines, which can also be used for bonding laminated tubing and for reducing and tapering solid or tubular stock. For a description of the process and its many advantages, write for Bulletin M-2060, or call in a Meta-Dynamics Division field engineer.

Laminated tubing
Material — Aluminum and copper
Operation—Bond copper lining to aluminum tube
Production — 24″ of tubing bonded per minute.

Left photo shows workpiece prior to Intraform operation. Note mandrel in front of part. Right photo shows workpiece after Intraform operation with profile of the mandrel reproduced in I.D. As workpiece feeds and mandrel does not, only a short, relatively inexpensive mandrel is required. Time for this operation was 16 seconds.



Intraform

META-DYNAMICS DIVISION

Machines for Metal Forming and Heat Treating

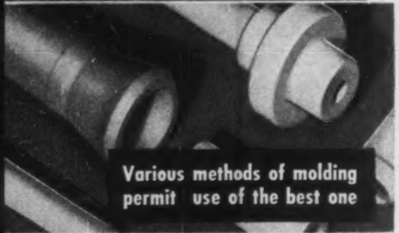
THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.

CINCINNATI

Extruded and machined parts . . .
8 different AlSiMag compositions

Pressed AlSiMag ceramics . . .
9 different compositions

Machined natural stone



Various methods of molding permit use of the best one

Casting handles larger shapes, odd contours

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the widest variety of technical ceramics from any single source

Specialized engineering talent in depth • The quantity you need . . . deliveries and quality as agreed • Special speedy service on prototypes • Specialized equipment for smaller quantity production • Unequaled facilities for volume production when you really need volume.

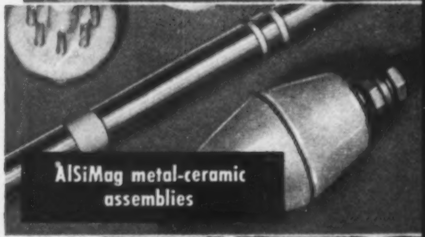
from one source . . .

These are typical samples picked up in our Inspection Department over a week end. They illustrate the great variety of technical ceramics constantly flowing through our ultra-modern plants.

Parts are shown approximately ½ size.

Property Chart Sent on Request.

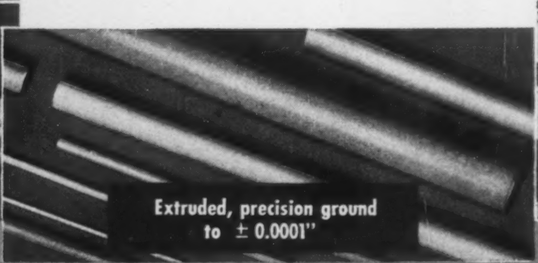
Odd contours can be handled in specialized molding processes



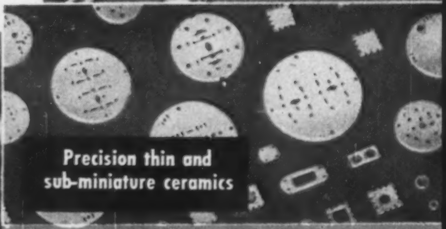
AlSiMag metal-ceramic assemblies

High temperature hermetic seals

Soft solder metalization



Extruded, precision ground to ± 0.0001"



Precision thin and sub-miniature ceramics

For more information, circle No. 370

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the firewall, required it to be tight enough to prevent the passage of fire, yet not so tight as to restrict the motion of the cable. It also had to be able to withstand 2000 F for 15 min. The final design was a 304 stainless steel bushing that shielded two TFE-impregnated asbestos washers.

One further problem remained: provision had to be made for replacing the asbestos washers when they became worn. Specifications dictated, however, that the seals be replaced without causing the 40-ft control cables to be restrung. This problem was solved by designing the bushing to be made in halves and slitting the washers. The nuts were also slotted so they could be passed over the cable (see accompanying photo).

Plans to machine the seal from stainless bar stock posed severe problems. To preserve concentricity, the stock would have to be split before it was turned. Machining the internal washer retaining grooves would be an extremely slow and difficult process. And there was always the possibility of mismatch.

The decision to investment cast the part was based on quotations indicating that it could be made cheaper as a casting than as a machined part.

ABS Pipe Resists Acid in New Research Lab

Over 10,000 ft of semi-rigid ABS (acrylonitrile-butadiene-styrene) pipe have been installed in Republic Steel Corp.'s new Research Center.

The pipe is used to carry dilute sulfuric and nitric acids.

According to Republic, this installation is one of the largest interior networks of plastics pipe in existence. ABS was selected because it has excellent resistance to acids and alkalis, is less expensive than conventionally used materials, and is easily installed. The pipe's smooth i.d. is another important factor in its selection; it prevents waste material from getting a "foothold" and clogging the drain.

The pipe is easily cut with an ordinary hand saw and joined by solvent cementing.

HOW TO BEAT THE HEAT

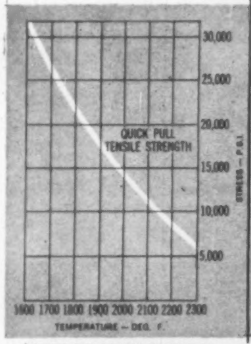
for strong high alloy requirements in the 1,800° to 2,300° F range!

DURALOY HOM*

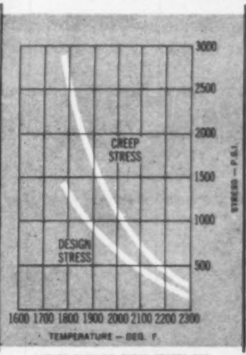
*Covered by U.S. Patents

casting alloy

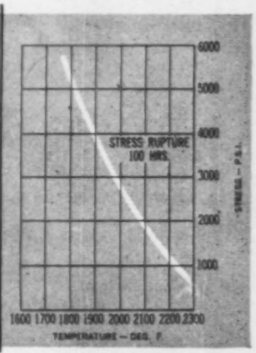
Duraloy "HOM" is a special high nickel alloy developed to produce castings that meet high temperature requirements, especially when castings are subject to oxidizing atmospheres.



CURVES SHOWING HIGH TEMPERATURE SHORT-TIME TENSILE STRENGTH OF DURALOY-HOM



CURVES SHOWING CREEP STRESS FOR CREEP RATE OF 1% IN 10,000 HOURS AND RECOMMENDED DESIGN STRESS FOR DURALOY-HOM



CURVE SHOWING STRESS TO RUPTURE AT 100 HOURS FOR DURALOY-HOM

Castings of DURALOY "HOM" are now being produced by our three methods: static, centrifugal and shell molded. Write today for additional information on this versatile new alloy.

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
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CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 415

It's not too late to win $500

in the 4th Annual Awards Competition for Best Use of Materials in Product Design

DEADLINE: FEBRUARY 1

16 CASH AWARDS	**FIRST AWARD** **$500** **and plaque**	**FIVE AWARDS OF MERIT** **$100 each** **and certificate**	**TEN CITATIONS** **$50 each** **and certificate**

Enter any new product or redesigned product, assembly, subassembly or single part that shows sound, imaginative or progressive use of engineering materials.*

**Engineering materials: metals, nonmetallics, finishes and coatings, and materials forms (such as castings, forgings, moldings, etc.)*

Rules of the Competition: A Brief Summary

(For complete details, see December issue, pp 107-110).

1. Materials producers or suppliers are not eligible.

2. The entry must have been designed, redesigned or put into production during the calendar year of 1959.

3. Provide the following information:

- **a.** A detailed description of the product, including photographs, drawings, before-and-after illustrations, etc.
- **b.** A description of the service and/or fabrication requirements that must be met by the product or material(s).
- **c.** A description of the material(s) previously used (if entry is a redesign).
- **d.** A description of the material(s) selected for the entry.
- **e.** An explanation of *how* and *why* the material(s) selected best met the design and service requirements or (if a redesign) resulted in improved performance and/or lower cost. Back up the selection of the material(s) with evidence—facts, data, charts and tables.

4. Entries or portions thereof will not be returned unless requested. Send copies, not originals, of valuable papers.

5. MATERIALS IN DESIGN ENGINEERING reserves the right to publish articles based on winning and nonwinning entries. Payment for non-winning articles published will be at usual rates. Judges reserve right to withhold awards at their discretion.

6. All entries must be postmarked not later than *February 1, 1960.*

For description of last year's award winners see May '59 issue, pp 121-144.

TO SEND YOUR ENTRY:

Use a separate blank for each entry; additional entry blanks available on request. Attach entry blank below, or its equivalent, to your entry and mail to:

Awards Editor, **Materials in Design Engineering,** 430 Park Ave., N. Y. 22, N. Y.

Name ____________________ Title ____________________

Name(s) of person(s), group or organization who would receive award ____________________

____

Company ____________________

Street address ____________________ City ____________________ State ____________________

Name or brief description of product being entered ____________________

____

Was design (or redesign) of entry either completed or placed in production during 1959? ____________________

Does your employer consent to entry under terms of this competition? ____________________

STRAITS
TIN
REPORT

MALAYAN TIN BUREAU

News of developments
in the production
and uses of tin

Nontoxic, inert, malleable – all three are descriptive of tin. One of man's oldest metals, it is still vital in our modern economy. For example –

For product protection, 60.7% of all tin consumed in the U.S. is used in manufacturing tinplate, largely for containers. 135 industries package a total of over 2500 products in more than 42 billion cans annually!

For joining and sealing, 14.8% of all tin used is in alloy with lead to form solder.

For strength and corrosion resistance, 6.5% is consumed in the tin-copper alloy, bronze.

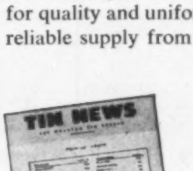
For anti-friction properties, 4.1% is consumed in the high-tin/lead alloy, babbitt, generic for bearing metals.

For protective coatings, tinning accounts for 3.9%. Hot-dipped tin provides a smooth, reflecting surface, particularly adaptable for food processing equipment.

For castability, white metal – alloys of tin, antimony, lead, bismuth, and copper – account for 3.2% of U.S. tin consumption.

Miscellaneous alloys use 4.2%; chemicals, 1.1%; and collapsible tubes, 1.5%.

There's no substitute for tin . . . and no substitute for Straits Tin from Malaya – recognized standard for quality and uniformity, available in reliable supply from sizeable reserves.



Write today for more data on these items or for a free subscription to TIN NEWS—a monthly bulletin on tin supply, prices and new uses.

The Malayan Tin Bureau
Dept. 24A, 2000 K Street, N.W., Washington 6, D.C.

For more information, circle No. 385

News OF INDUSTRY

Man's Mastery of Metals Symbolized by ASM Building

■ Striking use of metals marks the new headquarters building of the American Society of Metals.

Most prominent is the geodesic dome of aluminum tubing that juts over 100 ft into the air. As shown in the photo, the spiderweb-like structure partially straddles the low, almost semicircular building beneath.

Also prominent as one approaches the building is a large stainless steel sunshade with 4000 louvred "eyelashes" that baffle the direct rays of the sun.

Indoors, massive textured screens of copper are particularly interesting. But a variety of metals are used for hardware, stairs and furniture throughout the building.

Symbolism employed

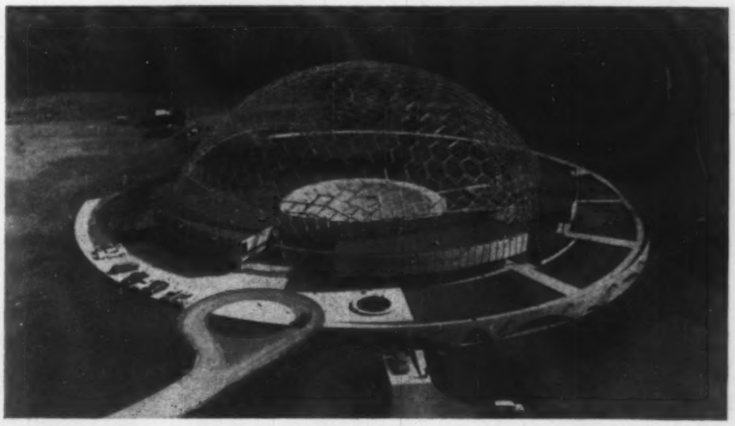
The ASM showed its new headquarters building to the technical press early last month. It is located in the rolling Ohio countryside on Rte. 87 of Cleveland.

The entire structure was designed to fit into the surroundings, creating a "garden" environment. The center of the area is a 100-ft dia saucer cut into the earth. When complete, this saucer-like garden will contain crude ores and minerals from all over the world—illustrating the metallic resources of the earth. The geodesic dome, 250 ft in dia, is centered over the mineral garden. It represents man's mastery of metals. Linking these two elements is the curved building housing man, the user of metals.

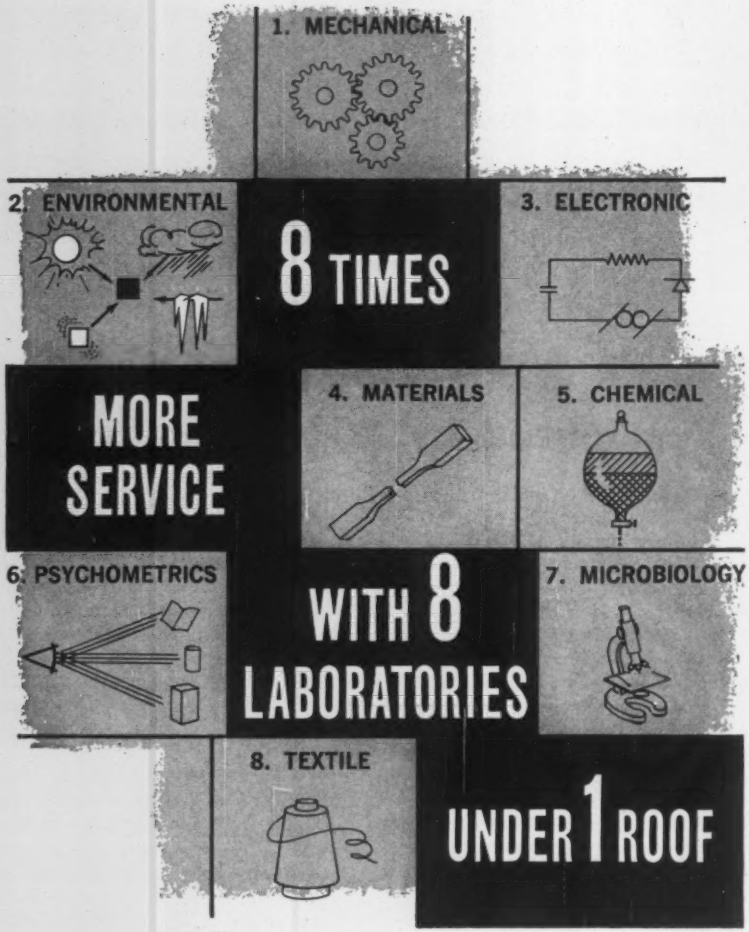
The headquarters building, on three levels, is constructed of reinforced concrete slabs and has glass curtain walls.

The architect was John Terence Kelly, of Cleveland. The geodesic dome was designed by R. Buckminster Fuller. Mr. Fuller has designed domes on the geodesic principle using virtually all important engineering materials.

The building is on a 100-acre plot donated for the purpose by the late William H. Eisenman who, for 40 years, was national secretary of ASM.



***ASM's new home** features an uncovered geodesic dome of aluminum.*



Whether it's a routine control analysis of an alloy, an environmental test of a "black box", or a complete structural and operating evaluation...whether it's appliances or batteries or turbines or valves...you get more from the **integrated laboratories** of United States Testing Company. Multi-million dollar facilities...career test engineers...a wealth of experience in your field...all these save you costly investment in laboratory equipment and give you top-quality testing and R/D services. Check *your* needs against the facilities and services available.

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For more information, turn to Reader Service card, circle No. 352

News OF INDUSTRY

Prepreg Committee Established by SPI

The Reinforced Plastics Div. of the Society of the Plastics Industry, Inc. has formed a Prepreg Committee (composed of producers of preimpregnated materials for reinforced plastics) which will be primarily concerned with establishing standard test methods and nomenclature.

Among the proposed test methods to be considered are tack, drape, gel time, and resin and volatile content.

Engineers

Charles M. White, Republic Steel Corp., has been named the recipient of the Benjamin F. Fairless Award given by the American Inst. of Mining, Metallurgical and Petroleum Engineers.

Joseph N. Guest has been named manager of production, Kidd Works, Vulcan-Kidd Steel Div., H. K. Porter Co., Inc.

Dr. John L. Zambrow has been appointed director of engineering, Sylvania-Corning Nuclear Corp.

Karl Franklin Mallory, Jr., has been named project engineer, Test Equipment Div., Consolidated Diesel Electric Corp.

Howard R. Fisher is now chief chemist, Parker Seal Co.

Terry F. Newkirk has been named manager, Ceramics & Metallurgy Div., Trionics Corp.

Dr. James E. LuValle has been appointed director of chemical research in the new physical chemistry laboratory of Fairchild Camera & Instrument Corp.'s Defense Products Div.

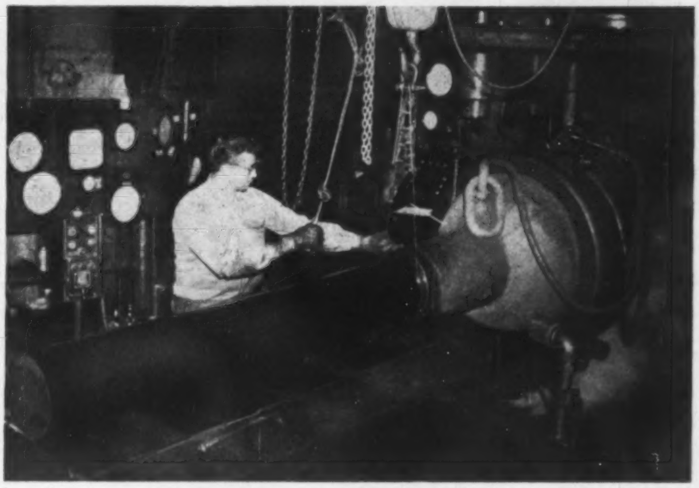
John L. Epps has been named plant manager, Triangle Mfg. Co.

Companies

General Mills, Inc. has acquired **Magnaflux Corp.,** which will be operated as a subsidiary of General Mills.

New Jersey Zinc Co. has announced a cash awards competition for the best examples of lightweight, thin-

HAVE YOU EXPLORED GRAPHITE As A Problem-Solving Material?



Are you looking for an economical substance that combines machineability, chemical inertness, high thermal conductivity, high temperature stability, resistance to thermal shock, corrosion resistance?

Are you looking for a material that has proved to be highly suitable for such diverse applications as vital nuclear reactor components, molds and dies for metals casting, sintering boats and trays, run-out tables and canisters, refractories, brazing fixtures, linings in chemical process equipment, thermocouple shields, and electric resistance furnace parts?

May we have the opportunity of helping you solve your materials design problem with some of the finest graphite being produced today by one of the largest graphite producers in the world?

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YOU CAN TRUST

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IF PHENOLICS CAN DO IT, PLENCO CAN PROVIDE IT—
AND DOES—FOR **EKCO PRODUCTS COMPANY**

FLINT® designers do their "pan-handling" with confidence...

they say, handle with

PLENCO

phenolic molding compounds

THE HOUSEWIFE may not know that her Flint stainless steel cookware handles are molded of Plenco phenolics, but she does know they'll never get too hot to handle. Knows they'll keep their gleaming good looks. Knows, too, they'll resist wear, shock, acids, grease.

Ekco Products, specifying Plenco 385 H.R. Black for handles, shares her confidence. For a higher-than-general-purpose heat resisting compound, this Plenco material possesses an unusually low specific gravity (1.45). More pieces per pound can be made with it, and the formulation is easy on the mold because of its extremely low mold erosion characteristics.

You can be sure that Plenco, with many years of supplying phenolic compounds to critical and competitive industry, has, or can *custom-formulate* the compound *you* need. We invite you to let us demonstrate that.

PLENCO PHENOLICS
FOR BETTER
PLASTIC PRODUCTS

**PLASTICS
ENGINEERING
COMPANY**
Sheboygan, Wisconsin

Serving the plastics industry in the manufacture of high grade phenolic molding compounds, industrial resins and coating resins.

For more information, turn to Reader Service card, circle No. 340

wall zinc die castings used in product design. The contest closes Jan 31.

Ling-Altec Electronics, Inc. announces a $600,000 expansion of its Anaheim, Calif. plant.

Leesona Corp. is the new name for **Universal Winding Co.,** Providence, R. I.

Jessop Steel Co. has acquired **Chase Steel & Supply Co.** of Los Angeles.

Marquardt Corp. has formed a Nuclear Systems Div., with Alan R. Gruber as director.

National Starch & Chemical Corp. has acquired **American Parboard Corp.**

Flintkote Co. and **Calaveras Cement Co.** have announced a merger whereby Calaveras Cement will become a division of Flintkote.

Howell Electric Motors Co., Howell, Mich., has acquired **Leland Electric Co.,** a former division of American Machine & Foundry.

Chance Vought Aircraft, Inc., has begun a million-dollar modernization of its heat treating facilities.

Vitro Corp. of America has consolidated its chemical and metallurgical operations to form **Vitro Chemical Co.,** a new subsidiary.

Waco Mfg. Co. has purchased **Transwall Folding Partition Div.,** Bemis Bro. Bag Co.

Spaulding Fibre Co., Inc. has begun construction of a new building to house six laboratory units at its research and development facility in Tonawanda, N. Y.

Kawneer Co. has acquired **South Bend Screw Products, Inc.**

Societies

Cast Bronze Bearing Institute, Non-Ferrous Founders' Society, announces the following national officers: president—William H. Crossman, Randall Graphite Bearings, Inc.; vice president—Carter N. Paden, Jr., Moccasin Bushing Co.; and secretary-treasurer—A. G. Eberle, Renewal Service, Inc.

American Standards Assn. announces the following 1959 recipients of its two highest awards: William L. Barth, formerly with General Motors Corp.—The Standards Medal;

Which picture do you fit?

Here are four *actual* customers* with different, but exacting product and technical needs. One uses Bridgeport rod in a range of alloys, the second Bridgeport strip. A third makes fasteners from Bridgeport Brass wire. The fourth company uses Bridgeport condenser tubes *and* Technical Service to produce quality heat exchangers. Which picture do you fit with your raw materials and manufacturing requirements?

"AUTOMATIC QUALITY," says Customer A. "We've a high-volume, automatic screw machine operation. Our alloy needs vary from job to job. Our production schedules demand *consistent* quality alloy and accurate gauge. With every rod alloy we get from Bridgeport, we get what we order . . . including aluminum alloys!"

"LONG-LENGTH COILS. They're one reason why we can depend on Bridgeport for strip," says Customer B. "Superior surface finish from Bridgeport saves us production costs. With their Sendzimir mill finish and exact gauge and width in long-length coil, you can see the reasons why we depend on Bridgeport for brass, copper and aluminum strip."

"CONSISTENT GAUGE. We need Bridgeport quality brass wire to make thousands and thousands of fasteners of every description," says Customer C. "High-speed, volume cold-heading production is only as good as the alloy wire that's used. Bridgeport Brass wire is made to exact tolerances for cold-heading at high speeds—we depend on it."

"PRODUCT PLUS SERVICE," says Customer D. "We manufacture heat exchangers for many applications. Our requirements include good technical and engineering service as well as a wide choice of brass, copper and aluminum tube alloys. All of these are available from Bridgeport."

*Names on request

These examples typify national metalworking opinions. There's no mystery why manufacturers the country over depend on Bridgeport—Bridgeport products and service are *close at hand*. The many brass, copper and aluminum alloys made by Bridgeport in rod, tube, wire and strip are *readily* available from stocks in your area; Bridgeport warehouses are located to make it easy for you to get what you want on time. Volume needs are mill-delivered. Your call to your nearest Bridgeport Sales Office, or a letter to Dept. 3501 will get you engineering and technical service. Try it, and you'll agree —you do fit into the picture!

BRASS Bridgeport CO.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Conn. • Sales Offices in Principal Cities

Specialists in Metals from Aluminum to Zirconium

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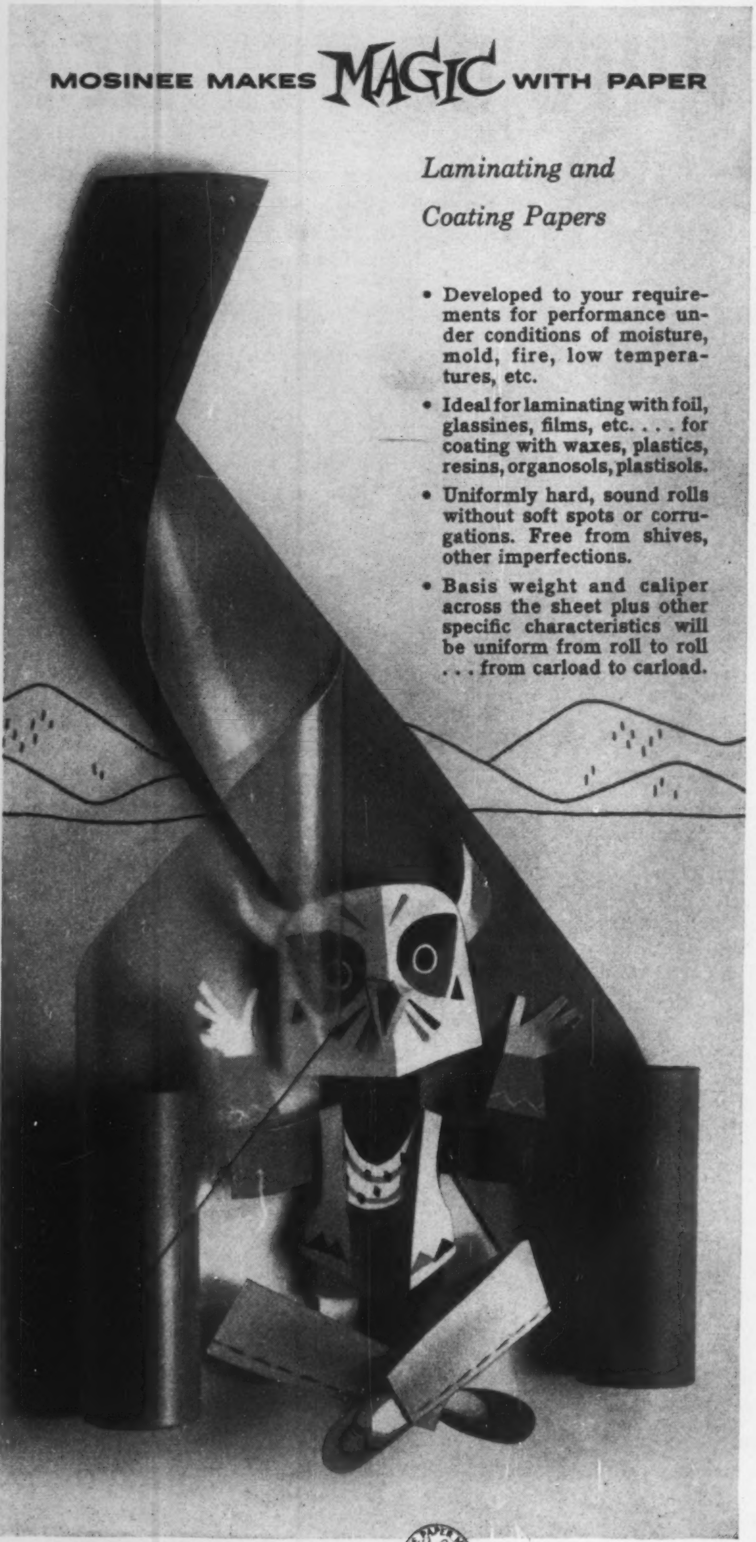

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- **Developed to your requirements for performance under conditions of moisture, mold, fire, low temperatures, etc.**
- **Ideal for laminating with foil, glassines, films, etc. . . . for coating with waxes, plastics, resins, organosols, plastisols.**
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News OF INDUSTRY

and Vincent dePaul Goubeau, Radio Corp. of America—The Howard Coonley Medal.

Society of the Plastics Industry's Epoxy Resin Formulators Div. has re-elected the following officers: chairman—L. R. Miller, Rezolin, Inc.; first vice chairman—John Delmonte, Furane Plastics, Inc.; and second vice chairman—Donald Roon, Houghton Laboratories, Inc.

Meetings

MALLEABLE FOUNDERS SOCIETY, semiannual meeting. Cleveland. Jan 15.

SOCIETY OF VACUUM COATERS, 3rd annual meeting. New York City. Jan 26-27.

AMERICAN SOCIETY OF HEATING, REFRIGERATION AND AIR-CONDITIONING ENGINEERS, annual conference. Dallas. Feb 1-4.

AMERICAN SOCIETY FOR TESTING MATERIALS, Committee Week. Chicago. Feb 1-5.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter general meeting. New York City. Feb 1-5.

INSTRUMENT-AUTOMATION CONFERENCE AND EXHIBIT, Instrument Society of America. Houston. Feb 1-5.

15TH SPI REINFORCED PLASTICS DIV. CONFERENCE, Society of the Plastics Industry, Inc. Chicago. Feb 2-4.

AMERICAN SOCIETY FOR METALS, 1960 Golden Gate Metals Conference. San Francisco. Feb 4-6.

AMERICAN INSTITUTE OF MINING, METALLURGICAL, AND PETROLEUM ENGINEERS, annual meeting. New York City. Feb 14-18.

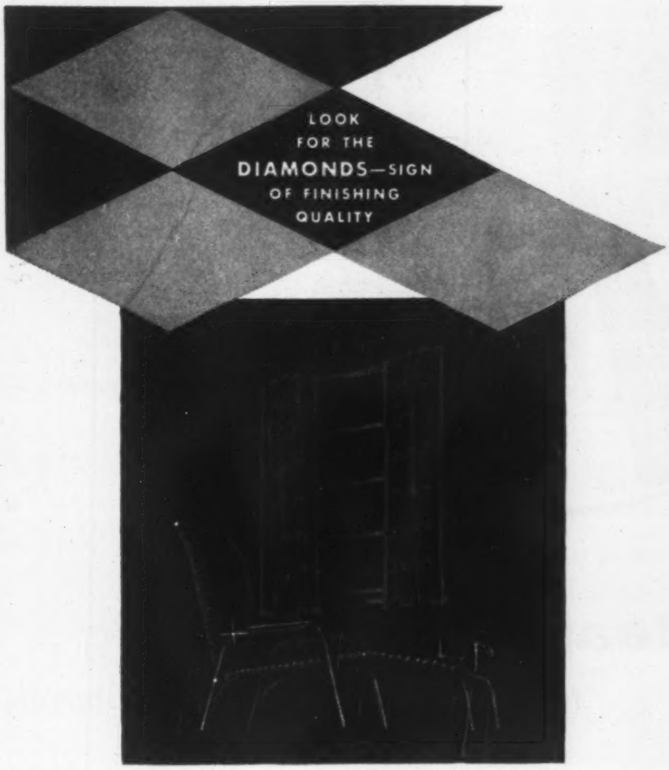
5TH NATIONAL ELECTRICAL INDUSTRIES SHOW, American Electrical Industries Expositions, Inc. New York City. Mar 6-9.

STEEL FOUNDERS' SOCIETY OF AMERICA, 58th annual meeting. Chicago. Mar 7-8.

SOCIETY OF AIRCRAFT MATERIALS AND PROCESS ENGINEERS, Mid-West Chapter, symposium on "Processing of Materials for Re-Entry Structures." Dayton, Ohio. Mar 9-10.

TEMPERATURE MEASUREMENT SYMPOSIUM, Instrument Society of America, Columbus, Ohio. Mar 9-11.

INSTITUTE OF RADIO ENGINEERS, INC., IRE national convention. New York City. Mar 21-24.



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An IRIDITE-IRILAC finish will provide longer life for storm doors, windows, outdoor furniture, auto parts and accessories, tubing or wire goods. And, you have a choice of color finishes such as natural aluminum and golden yellow. Other colors may be obtained by an additional dye operation.

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IRILAC over an IRIDITE No. 15 finish increases corrosion protection, and provides resistance to finger printing and abrasion on all types of products, with color appearance ranging from light to dark brown.

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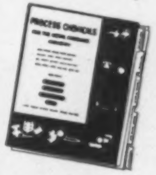
IRIDITE plus IRILAC gives your product longer life and brighter appearance. Color choices range from clear IRIDITE to olive drab, plus colored dye finishes.

IRIDITE is the tradename for a specialized line of chromate conversion coatings that can be applied to any non-ferrous metal by brush, dip or spray methods—at room temperatures—manually or with automatic equipment. Upon application, a thin film forms which becomes an integral part of the metal itself, and thus cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel are required.

IRILAC is the tradename for a line of clear protective coatings for all metals. As safe and easy to handle as water, they may be applied by brush, dip or spray methods. No exhaust or special fire protection equipment required. Adds protection and abrasion resistance to any base metal, plated part or parts treated with electrolytic or chemical post treatments, without chemical change.

For complete technical information on IRIDITE Chromate Conversion Coatings or IRILAC Clear Protective Coatings, write for FREE TECHNICAL MANUAL. Or, see the Allied Field Engineer in your area. He's listed under "Plating Supplies" in the yellow pages.



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Continued from p 104

Six Major Reasons for Using Aluminized Steel Products

Within the past ten years aluminized steel has emerged from relative obscurity and is now gaining favor over galvanized steel in a number of applications. Market analysts and research people give six major reasons for increased use of aluminized steel:

1. *Good corrosion resistance*—Tests show that aluminized steel has better resistance to industrial and marine atmospheres than galvanized steel. Aluminum forms a thin, colorless oxide layer on its surface which protects the basis metal against corrosion. This oxide layer "heals" itself through rapid reoxidation when the coating is scratched.

A zinc coating, on the other hand, forms corrosion products that are soluble in water, particularly in sulfurous industrial atmospheres. The protection of the zinc coating is gradually lost by dissolution of zinc through galvanic action.

Although the corrosion resistance of both aluminized and galvanized steel is excellent in rural atmospheres, the aluminized steel retains its lustrous appearance longer.

2. *Good oxidation resistance*—Aluminized steels are resistant to oxidation at temperatures up to 1800 F.

3. *Pleasing appearance*—The appearance of aluminized steel is similar to that of solid aluminum, and is superior to the appearance of most galvanized steels after weathering. Weathering tends to dull the galvanized surface but normally leaves the aluminized surface in its original condition.

4. *Good radiant heat reflector*—Aluminized steel reflects about 80% of radiant heat at temperatures up to 900 F. The thermal conductivity of aluminized steel is considerably better than that of uncoated or alloyed steel, since aluminum is an excellent conductor of heat.

5. *Good for fastening steel to aluminum*—Aluminized fittings and fasteners prevent dissimilar metal contacts in products where aluminum is used with steel.

6. *Good base for porcelain enamel*—Aluminizing can be used to pro-

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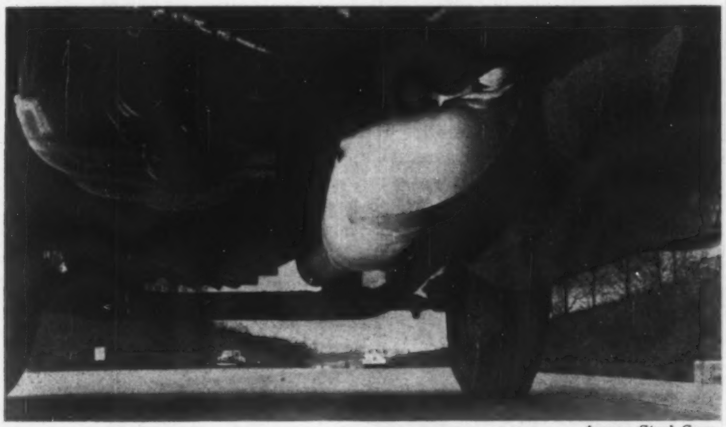
Based on an article appearing in the May-June '59 issue of *Kaiser Aluminum News*, published by Kaiser Aluminum & Chemical Corp., Kaiser Bldg., Oakland, Calif.



Armco Steel Corp.

Automobile muffler *is protected with aluminum coating.*

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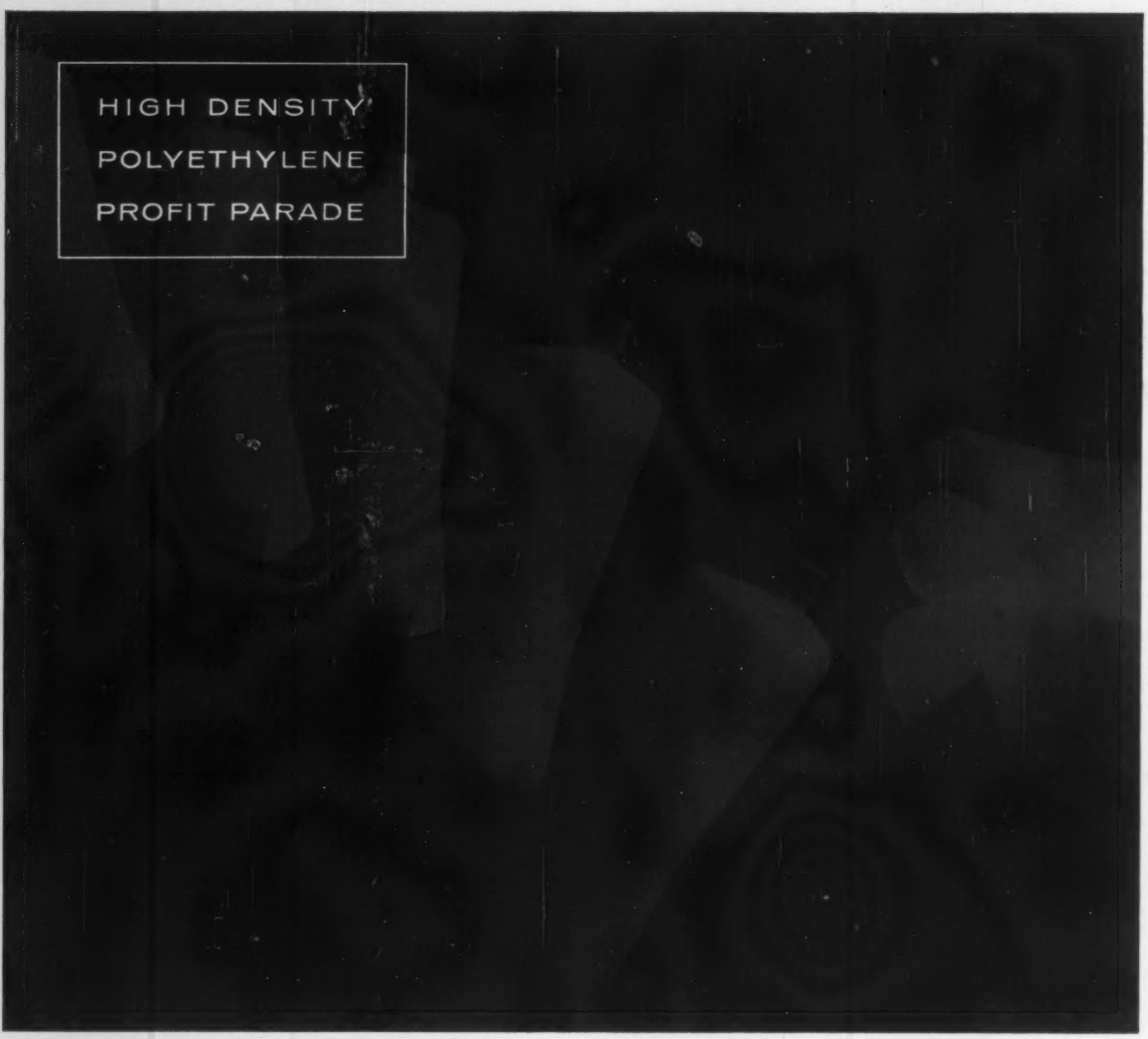

Plastics Development Pays Off for Hollow Products

If hollow products, parts or containers are important in your business you should know what blow molding and high density polyethylene from Grace have to offer. These dent-resistant, durable bottles by Owens-Illinois show a few of the benefits never before realized with other plastics and fabricating techniques.

High density polyethylene can be used to produce hollow objects such as these bottles that are featherweight yet remarkably rigid and strong, even in thin wall sections. Economies in production and raw materials naturally follow. In addition, these bottles are resistant to abrasion and virtually indestructible. They withstand refrigeration without cracking, autoclaving without distortion and exposure to most chemicals. Significantly, the Owens-Illinois no-drip bottles are comparable in cost with many of today's packages.

Blow molding also permits the use of Grex resins that result in superior strain-free characteristics, often difficult to achieve by other techniques.

Sound interesting in terms of the products you make? Then you'll also be pleased with the surprisingly low mold costs, too. For the full story on this versatile plastics development call in the high density polyethylene experts. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

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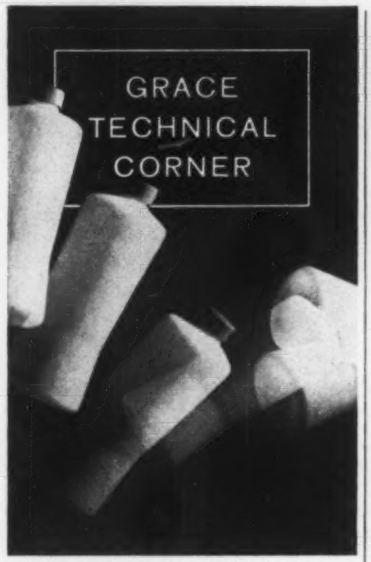


Blow molding with Grex offers fabricating economies and new product possibilities.

Blow molding is today's fastest growing fabricating technique—and no plastics lend themselves to blow molding better than high density polyethylene. This holds true whether the application is as straightforward as these Owens-Illinois bottles, or as complex as toy cars large enough to hold a child. Here are a few reasons behind the boom in blow molding with high density polyethylene:

Savings in mold and equipment costs. Because of the low pressures involved in fabricating Grex by this technique, lightweight molds can be made of easily toolable materials. Thus mold costs are ⅛ to ⅓ less than for any other fabricating method. Furthermore, blow molding is a simplified technique, often adaptable to existing injection molding and extrusion equipment.

Economies in resin requirements and cycle times. The physical properties of Grex (rigidity, heat distortion resistance, abrasion resistance) permit blow molding of thin wall sections. As a result, less resin is used per molded piece. Cycle time—even for large parts—is also reduced. Cycles in blow molding are limited only by the time it takes to cool a part. Thinner walls made possible by the characteristics of high density polyethylene speed cooling and cut cycles.

Ease of molding. Complex shapes with serious undercuts, often difficult to blow mold with other plastics, rarely present problems when a Grex blow molding resin is specified. In fact, fabricators find this technique permits use of resins having superior physical properties without sacrificing moldability. Also inherent in blow molding is the fact that costly assembly operations are held to a minimum. The large toy car, for example, is blown in a single piece.

Find out more. If you have an application for blow molding with high density polyethylene—or think you have—count on Grace for help. Write now to:

Technical Service Department
W. R. Grace & Co., Clifton, N.J.

Ten Aluminizers

Consumption of aluminum for coating purposes jumped from 92,000 lb in 1951 to 4,076,000 lb in 1958. Suppliers of aluminized steel products have also increased from a few in 1951 to the 10 companies listed here:

1. American Chain & Cable Co., Page Steel & Wire Div., Box 692, Monessen, Pa.
2. Armco Steel Corp., 703 Curtis St., Middletown, Ohio.
3. Sheffield Div., Armco Steel Corp., Sheffield Sta., Kansas City 25, Mo.
4. Bethlehem Steel Co., 701 3rd St., Bethlehem, Pa.
5. Light Metals Processors, Redwood City, Calif.
6. Republic Steel Corp., Republic Bldg., Cleveland 1, Ohio.
7. John E. Roebling & Sons, 640 S. Broad St., Trenton 2, N. J.
8. Arthur Tickle Engineering Works, Inc., 21 Delevan St., Brooklyn 31, N. Y.
9. United States Steel Corp., 525 Wm. Penn Pl., Pittsburgh 30.
10. American Steel & Wire Div., U. S. Steel Corp., Rockefeller Bldg., Cleveland 13, Ohio.

---

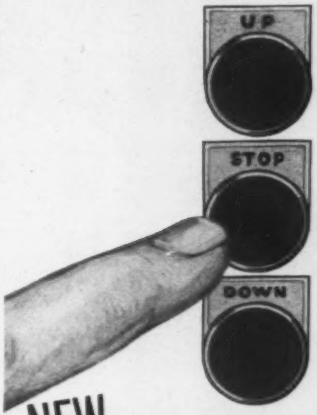
vide a base for porcelain enamels and other nonmetallic coatings.

What about cost?

Materials costs for aluminum and zinc coatings are comparable for equal thicknesses of coating. Generally, the coating thickness for aluminum and zinc is about the same, falling in the range of 1 to 4 mils. However, aluminum will cover a greater surface area for a given coating thickness and weight because it has a greater specific volume than zinc.

Operating costs have not been firmly established for aluminizing. It appears that aluminizing costs may run slightly higher than galvanizing costs because of the higher temperatures and greater care required for aluminizing steel successfully. Galvanizing temperatures range between 750 F and 850 F; aluminizing temperatures between

THE SURE TEST . . . SCOTT!



NEW PUSH-BUTTON SIMPLICITY REVOLUTIONIZES PHYSICAL TESTING

TEST AT A TOUCH! Simple push-button operation of the Scott Model CRE Electronic Tester provides complete crosshead control, and a wide range of test capacities . . . enabling even the non-technical operator to obtain test results faster, easier, and at amazingly low cost!

FINGER-TIP CONTROLS for a variety of crosshead speeds also add to operating convenience and ease. No manual gear changes. No weight-handling, either. The Scott Constant-Rate-of-Extension Tester gives you the ultra-high accuracy of inertialess weighing . . . *plus* effortless operation that takes all the work out of physical testing.

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Silicone heat resistant finish
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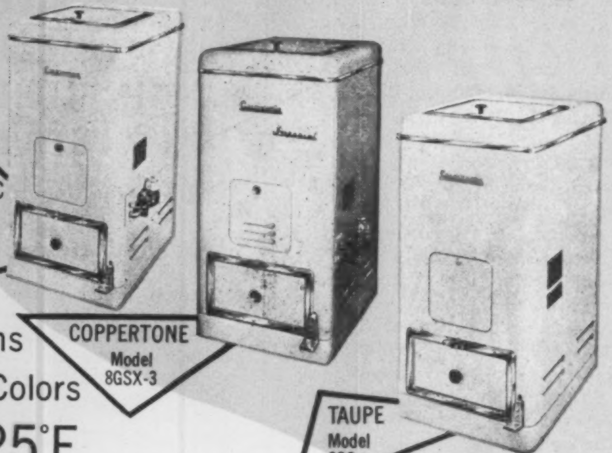

Retains Rich Colors at 425°F. with excellent adhesion and mar resistance

Sicon, the first high temperature finish to break the "heat barrier" in colors, is specified for all Calcinator home incinerators. A wide range of colors is employed: Metallic Blue, Coppertone and Taupe, as shown above; also Yellow and Turquoise. These smart Sicon enamels lend compelling eye-appeal on the sales floor. Equally important, their ability to retain their rich colors and gloss in every day service—exposed to temperatures in the 425°F. range—has helped produce thousands of satisfied Calcinator users. Sicon is easy to apply by brush, spray or dip. At Calcinator it is hand sprayed and baked by gas-fired ovens for 20 minutes at 425°F.
Sicon's excellent adhesion and film stability has led to its use on scores of applications, of widely varying heat resistance requirements up to 1000°F. Midland engineers will be glad to analyze your problem and suggest a formula. Send us all details.

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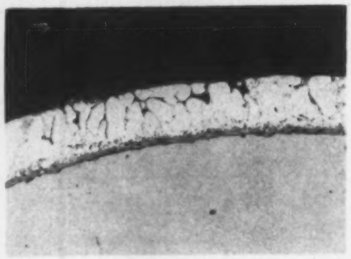

Microstructure *of aluminized steel.*

1250 F and 1400 F. Particular care is required in cleaning steel prior to aluminizing, and this may be more costly than the cleaning required prior to galvanizing. In general, however, it is believed that hot dip aluminized steel products will be competitive in price with hot dip galvanized steel products.

Applications

Products that are presently being aluminized include steel forgings, cast iron parts, chain link and barbed wire fence, automobile valves, sheet metal products, furnace parts, baking pans, roofing, and automobile mufflers.

A potentially large market for aluminized steel is the electrical transmission and distribution industry where aluminized pole-line hardware, telephone wire and ASCR core wire offer substantial advantages over other coated products. Other end uses in sight are bridge plates, heavy industrial equipment, refrigerator cars and garbage cans.

Heat Treating Improves Welds in Type 347 Steel

Welds in type 347 stainless steel piping should always be given a post-weld solution heat treatment to insure good service life, says R. J. Christoffel of the Large Steam Turbine-Generator Dept. of General Electric Co., Schenectady, N. Y.

Reason: cold working during welding reduces the notch rupture strength of the heat-affected zone in type 347 weld joints. This low notch rupture strength in the presence of welding and service stresses can cause the piping to crack.

The post-weld heat treatment (2 hr at 1100 F, 2 hr at 1925 F, and

it adds*
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The Victor Adding Machine Company was looking for a machine housing that was practically indestructible. It had to withstand hard blows, staining, fading, and wear. CYCOLAC, the tough, hard, rigid ABS plastic from Borg-Warner, proved it could do the job—and economically, too! It was given every test—even thrown down stairs!—yet it came through like a champion. Every day more leading manufacturers discover how much CYCOLAC can improve their products. Why not find out what it can do for **yours?**

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air cooling to room temperature) dissolves and spherodizes ferrite in the weld metal, relieves residual welding stresses, and improves the notch rupture strength of the heat-affected zone.

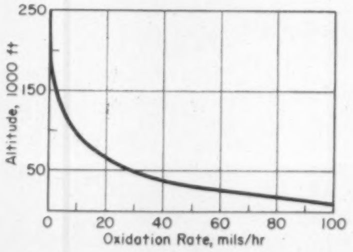
Christoffel made these recommendations at a metals engineering conference sponsored by the American Society of Mechanical Engineers last spring in Albany, N. Y.

Molybdenum Oxidizes Less at High Altitudes

Unalloyed and uncoated molybdenum metal oxidizes more slowly at high altitudes than at sea level when exposed to a temperature slightly over 2000 F. The graph shown here indicates that the metal has a 100-fold reduction in oxidation at an altitude of 175,000 ft as compared to its oxidation at sea level.

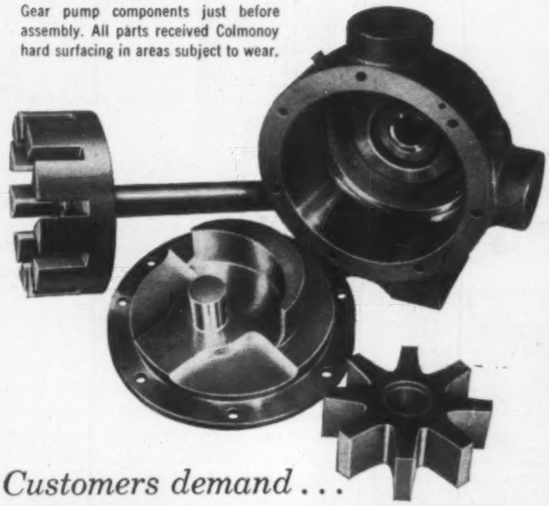
From these data it might be assumed that hypersonic aircraft and missiles operating at high altitudes could use uncoated molybdenum structures provided low ambient pressures cause a sufficient reduction in rate of oxidation.

The graph was plotted from the results of tests conducted at the Missile Div. of North American Aviation, Inc., Downey, Calif. The tests were conducted to determine the relationship between air pressure (altitude) and rate of oxidation of molybdenum at 2080 F. The strength-weight ration of molybdenum is said to be superior to that of other metals at this temperature. Previous work on the oxidation of molybdenum at high altitudes was done at temperature below 1500 F.



Oxidation rate *of molybdenum at 2080 F vs altitude.*

Gear pump components just before assembly. All parts received Colmonoy hard surfacing in areas subject to wear.



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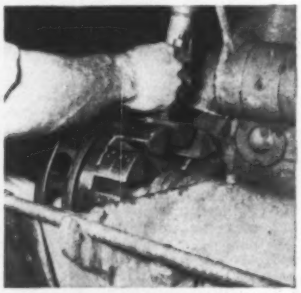
Colmonoy Hard-Surfaced, Long-Lasting Gear Pumps

Pump users know Colmonoy lengthens pump life . . . some manufacturers who know they know it now provide Colmonoy protected parts in new pumps.

Pump components that can be lathe-mounted are easily hard-surfaced with the Colmonoy Spraywelder. A Colmonoy nickel-base alloy Sprayweld* Powder (there are 5 grades) is applied to the wear-areas. The sprayed overlay is fused to the base metal, creating a non-porous, wear resistant surface. Irregularly shaped parts are overlaid with easy-to-apply Colmonoy oxy-acetylene rods of the same alloy grade.

Get expert advice on your particular needs. Call in a Colmonoy sales engineer or write Detroit.



Above: The Colmonoy Sprayweld unit. Left: Colmonoy overlay on pump rotor being finish ground. Below: The Spraywelder Catalog and Colmonoy Manual. Ask for them.

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*Registered trade-mark

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This mix is melted under accurately-controlled temperatures and the molten glass is pressed to exact dimensions in Kopp-engineered molds. Subsequent cooling, annealing, grinding and finishing—under strict quality control—provide the components to meet your design requirements *exactly*.

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Kopp Glass, INC.
Swissvale, Pennsylvania

For more information, turn to Reader Service card, circle No. 331

TECHNICAL LITERATURE

(cont'd from p 49)

Books

Nondestructive Testing Handbook. *Edited by R. C. McMaster. Ronald Press Co., New York. 1959. Cloth, 6 by 9 in. Price $24 (two volumes)*

Volume 1. *985 pp.* Discusses field and maintenance tests, liquid penetrant tests, radiation detection and recording, x-ray diffraction and fluorescence, film radiography, visual inspection, high voltage radiography, radiation protection, xeroradiography, and x-ray control of weldments.

Volume 2. *915 pp.* Discusses electrified particle, eddy current, ultrasonic, magnetic-field, natural frequency vibration, brittle coating, resistance strain gage and photoelastic tests.

ASTM Standards on Wood, Wood Preservatives, and Related Materials. *American Society for Testing Materials, Philadelphia. 1959. Paper, 6 by 9 in., 456 pp. Price $5.50*

Specifications, methods of testing and definition of terms relating to wood and wood preservatives.

Indium. *Compiled by Maria T. Ludwick. Indium Corp. of America, Utica, N. Y. 1959. Cloth, 6 by 9 in., 770 pp. Price $10*

Information on the discovery, occurrence, development and chemical characteristics of indium. The book gives properties and uses of binary, ternary, quaternary and quinary indium alloy systems. It also contains an annotated bibliography of all publications on indium from 1863 to 1958.

Directory of Steel Foundries in the United States, Canada, and Mexico: 1959-60. *Steel Founders' Society of America, Cleveland, Ohio. 1959. Paper, 6 by 9 in., 260 pp. Price $15*

Gives information on types of castings produced, weight range, special processes such as centrifugal casting and shell molding, nondestructive testing equipment, the number of employees, and the rated monthly capacity. A limited edition of 1100 copies has been printed.

Magnetic Properties of Metals and Alloys. *American Society for Metals, Cleveland, Ohio. 1959. Cloth, 6 by 9 in., 355 pp. Price $8*

Subjects covered in this book are: 1) magnetism, 2) measurement of magnetic properties, 3) magnetic domain structures, 4) metallurgical structure and magnetic properties, 5) magnetic properties of thin films and fine particles, 6) time effects in magnetization, 7) magnetostriction, 8) magnetic annealing, 9) magnetomechanical damping, and 10) nuclear magnetic resonance in magnetic crystals.

Compilation of ASTM Standards Relating to Coated and Uncoated Iron and Steel Sheet and Strip: A-1, A-5. *American Society for Testing Materials, Philadelphia. 1959. Cloth, 6 by 9 in., 148 pp. Price $3*

Contains 21 standards including 11 specifications for steel sheet and strip, three specifications for metallic-coated steel sheet, two

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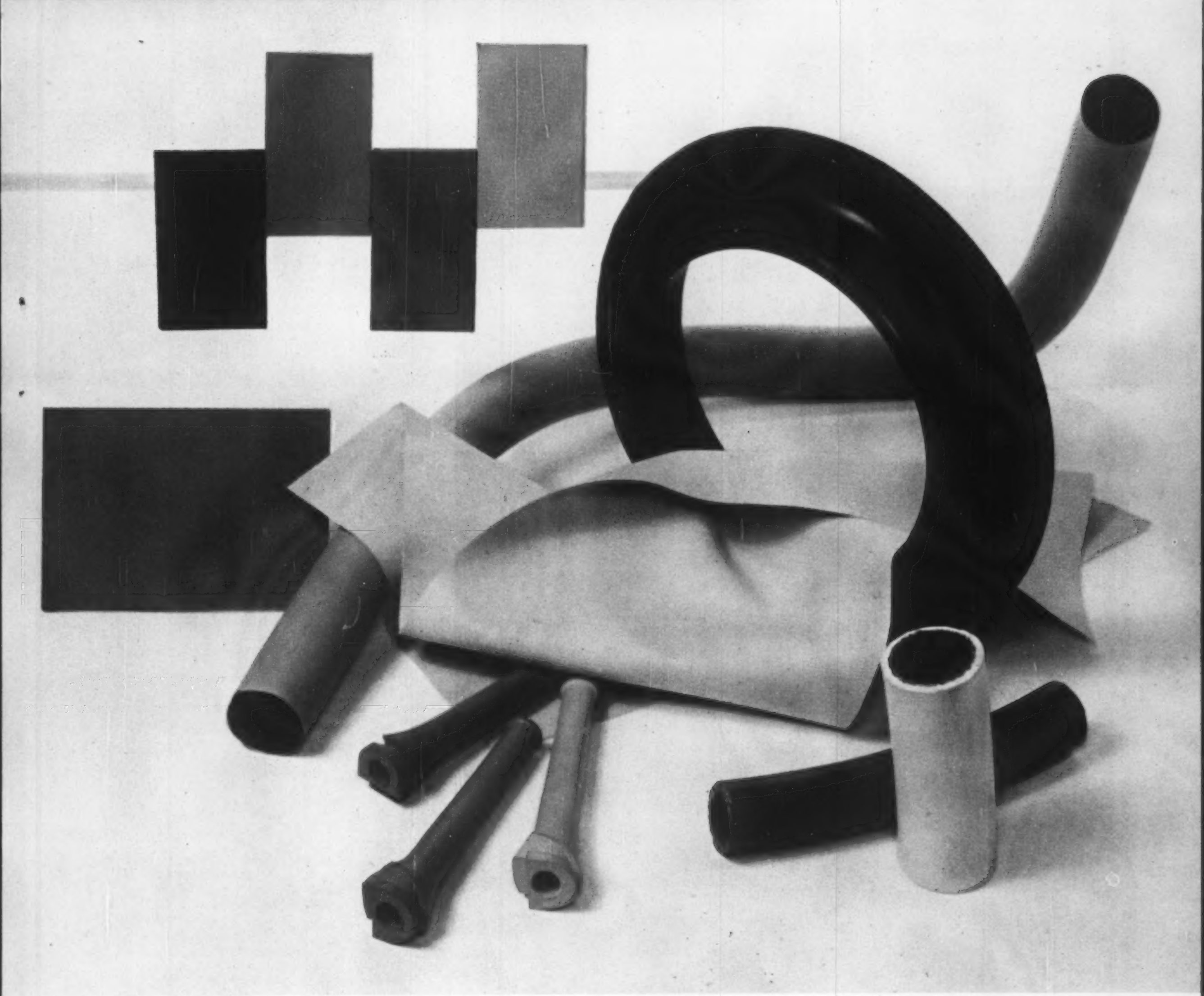

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specifications for wrought iron sheet, one specification for metallic coating materials and four methods of test.

The Surface Treatment and Finishing of Aluminum and Its Alloys: 2nd Edition. *S. Wernick and R. Pinner. Robert Draper Ltd., Teddington, Middlesex, England. 1959. Cloth, 5½ by 8½ in., 607 pp. Price $13*

Discusses corrosion and protection of aluminum and its alloys, mechanical surface treatments and finishes, electro and chemical polishing, cleaning and etching, chemical conversion coatings, anodizing, coloring processes, organic finishing, plating, vitreous enameling and metal spraying of aluminum.

Sampling Inspection Tables, Single and Double Sampling: 2nd Edition. *H. F. Dodge and H. G. Romig. John Wiley & Sons, Inc., New York. 1959. Cloth, 8½ by 11 in., 234 pp. Price $8*

Nomography: 2nd Edition. *A. S. Levens. John Wiley & Sons, Inc., New York. 1959. Cloth, 296 pp. Price $8.50*

Theory and construction of charts involving straight line scales, curved scales and combinations of the two.

Reports

Effect of radiation on lubricants THE BEHAVIOR OF FUELS AND LUBRICANTS IN DYNAMIC TEST EQUIPMENT OPERATING IN THE PRESENCE OF GAMMA RADIATION. *M. Z. Fainman and others, Inland Testing Laboratories Div., Cook Electric Co. Mar '58. 198 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $3 (PB 151701)*

Gives relative ratings of ten military fuels and six lubricants that show the best performance characteristics for potential use in nuclear powered aircraft. The major objective of the program was to evaluate the performance in radiation environments of fuels, hydraulic fluids and lubricants developed by various Air Force contractors.

Cutting titanium sheet ROUTING OF TITANIUM SHEET. *C. T. Olofson, Battelle Memorial Institute, Ferrous Metallurgy Div. June '59. 6 pp. Available from Defense Metals Information Center, Battelle Memorial Institute, Columbus 1, Ohio. (No. 22)*

Describes a method for cutting titanium sheet into shaped blanks.

Ferromagnetic films THE PREPARATION AND CHARACTERISTICS OF THIN FERROMAGNETIC FILMS. *Air Force Cambridge Research Center. Nov '58. 139 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.75 (PB 151525)*

Study shows that thin nickel-iron alloy films with characteristics suitable for use in computers can be prepared by an electrochemical process and by thermal decomposition of acetyl acetonate on a wide variety of substrates. The films are produced with a wide range of compositions, thicknesses and magnetic properties.

Impact resistance of plastics IMPACT AND SHOCK RESISTANCE OF PLASTICS: FINAL REPORT. *North Carolina State College. Dec '57. 35 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.25 (PB 151729)*

Describes a pendulum type impact machine (Raleigh-Edwards-Tensile-Impact-Machine-Pendulum) used to test the impact and shock resistance of plastics.

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National can now furnish extrusions or fabricated parts of this remarkable new Du Pont thermoplastic

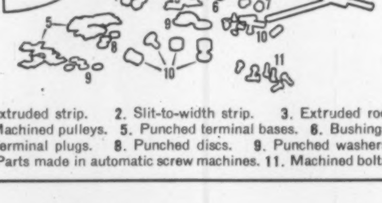
If you have not yet evaluated this exciting new material you will want to. Exhaustive tests show that "Delrin" can compete on a cost and performance basis with parts made of many metals, rubber, glass or wood. It may be the *one best material* to solve a current problem for you.

In adding "Delrin" to its family of thermoplastics, National continues the policy of offering the designer industry's widest selection of basic materials—over 100 types and grades. "Delrin" is available in extruded rod, strip, and special shapes, or in precision fabricated parts to your design. You can depend on National's production experience for sound help on "Delrin" applications.

Sizes now available include: rod—¼" to 2" diameter; strip—.020" through .093" thick, up to 7" wide.

Special extruded shapes available upon request. Fabricated "Delrin" parts now being furnished National's customers indicate broad application wherever strength, rigidity and dimensional stability are important.

For specific information, prices and personal assistance on the use of "Delrin"—or any of the more than 100 National materials—write National Vulcanized Fibre Co., Dept. KK-1, Wilmington, Delaware. Or contact your nearby National Sales Office.



1. Extruded strip. 2. Slit-to-width strip. 3. Extruded rod. 4. Machined pulleys. 5. Punched terminal bases. 6. Bushings. 7. Terminal plugs. 8. Punched discs. 9. Punched washers. 10. Parts made in automatic screw machines. 11. Machined bolts.

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PEERLESS Electrical Insulation: coil, strip, corrugated.

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Polyester Glass Mat: 4 standard sheet grades; custom molded shapes.

PHENOLITE Copper-Clad Laminates: 10 standard grades.

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(Continued from p 14)

What's new IN MATERIALS

that will produce bars of unlimited length, feeding them directly into a sintering furnace and from there to further processing stations.

The accompanying table contains typical experimental results obtained by continuous compaction of various metal and alloy powders.

For more information, circle No. 604

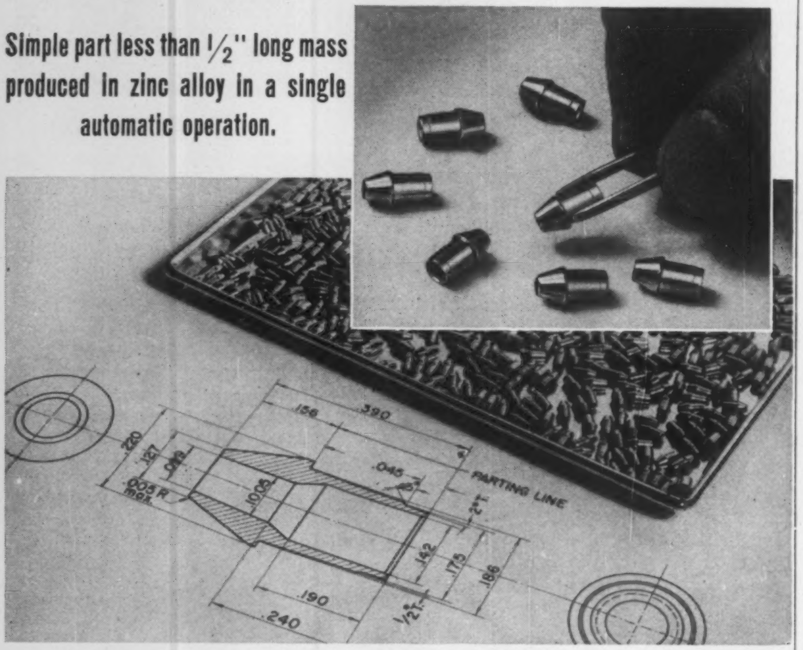
TYPICAL EXPERIMENTAL RESULTS OF CONTINUOUS COMPACTION

Material ↓	Compacting Load, tons	Pressed Size, in.	Sintered Density, % of theoretical	Results, Remarks
Copper				
Pressed	60	0.25 x 2 x 28	90	Excellent bars and very easy to compact
Repressed	100	0.23 x 2 x 28	94	Slight surface marking from repressing
Electrolytic Iron	60	0.50 x 2 x 24	—	Good bars if powders are freshly annealed
Easton RZ Iron	60	0.625 x 2 x 28	71	Excellent bars
Tungsten + 1% Paraffin				
Pressed	30	0.50 x 2 x 24	61	Good appearance, but binder and low compacting pressure are necessary
Repressed	40	0.75 x .75 x 30	—	To be used as consumable electrode
Molybdenum	15	0.50 x 2 x 24	82	Good bars. Low green density, heavy shrinkage
Columbium Sponge	50	0.75 x .75 x 26	—	For use as consumable electrodes. Green bar is very flexible
A-104 Iron Sponge	50	0.75 x .75 x 26	—	For use as consumable electrodes. Green bar is very flexible
Titanium Sponge	50	0.25 x 2 x 28	—	Compacts nicely. Used for "getter" sheets in sintering
Ni-Al-Fe Alloy	95	0.50 x 2 x 28	—	Compacts well
Fe-Co-V Alloy				
Pressed	50	0.15 x 2 x 24	62	Excellent bars.
Repressed	100	0.12 x 2 x 24	89	Slight surface marking. Subsequently processed to 0.004 in. tape
Iron-Clad Copper	60	0.30 x 2 x 12	—	Excellent bar. Special powder filling technique was necessary

(more What's New on p 160)

GRC DIE CASTING METHODS CUT TINY BUSHING COSTS TO $2/M

Simple part less than 1/2" long mass produced in zinc alloy in a single automatic operation.



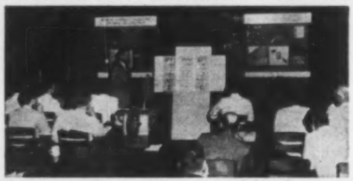
This tiny bushing is used in a ball point pen. Overall it is .390" long and .220" wide. It was formerly made on screw machines, but Gries Reproducer Corporation was able to die cast it in zinc alloy in a single automatic operation reducing the cost to little more than $2.00 per thousand. In addition to lowering cost substantially, GRC exclusive methods guaranteed the perfect uniformity of each individual piece in the million part run. The manufacturer also took advantage of GRC's service to their customers on secondary operations and had the part nickel plated.

Not only in this case, but in many others in which both commonplace and extremely intricate parts were involved, Gries' unique patented die casting techniques have made possible exceptional savings and broad flexibility in design.

A fact-filled die casting bulletin, yours for the asking, is put out by GRC explaining their exclusive methods and showing how Gries has helped solve problems on parts "no bigger than your thumbnail" (maximum is 1¾" long, ½ oz., no minimum).

Yours for the asking —GRC HANDY GUIDE TO LOW COST QUALITY FASTENERS

GRIES OFFERS NEW VALUE ANALYSIS SEMINAR SERVICE



To acquaint engineers with the economic and design advantages of utilizing Gries' precision small die castings and plastic moldings, GRC has organized a New Value Analysis Seminar. The packaged program, conducted at your plant, is supplemented with visual aids and highlights, examples of successful cost reductions achieved through high speed, automatic production of tiny parts.

The seminars are designed to serve as a valuable tool for improving productivity and lowering costs. To arrange for the seminar or to learn more about this significant series please write to GRC's Value Analysis Dept.

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What's new IN MATERIALS

Six Organic Coatings for Metal Products

As is customary, many coating formulators and raw materials suppliers timed their latest new product announcements to coincide with the Annual Paint Industries Show. The Show, held in conjunction with the 37th Annual Meeting of the Federation of Paint and Varnish Production Clubs in Atlantic City, Oct '59, set the scene for several coating announcements which are of particular interest to product designers and engineers.

Solvent-free epoxies applied with conventional equipment

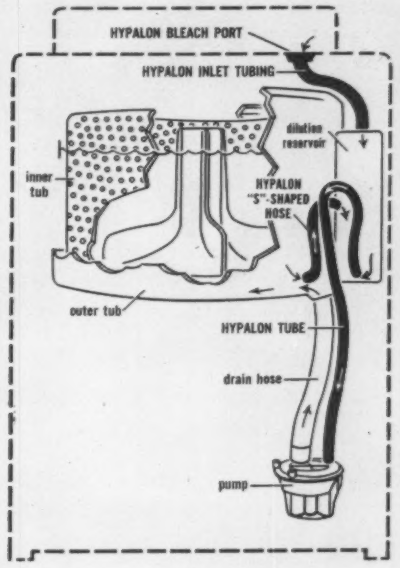
The 100% solids, solvent-free epoxy coating first announced at the '58 Show (see M/DE, Jan '59, p 154) can now be applied with conventional spray equipment.

Previously, the liquid epoxy base and the curing agent either had to be mixed in small batches with a usable life of only 15 to 20 min, or else required special spray equipment which metered and mixed the components just before atomization. However, with the development of new curing agents, it is now possible to mix large batches of the coatings which have a pot life of several weeks and which can be used in ordinary spray guns without danger of clogging.

Specialists from Shell Chemical Corp., 50 W. 50th St., New York 20, the materials supplier, also claim that the new curing agents improve properties of coatings applied in damp atmospheres. Coatings cured with most conventional curing agents show a severe blush or frosting when applied during high humidity. This problem is practically eliminated with the new curing agents.

The new curing agents make it possible to apply single coats up to 10 mils thick without bubbling or sagging. Furthermore, since the coatings do not contain any solvents they completely eliminate fire hazards. For these reasons the coatings are well suited for lining storage tanks, marine ballast and cargo

For more information on new materials, note key number and circle it on Reader Service card.



MAYTAG TIMED BLEACH INJECTOR. Concentrated chlorine-type bleach is poured through the bleach port into the dilution reservoir. Here it is diluted four times by water from the tub. Diluted bleach is metered to the pump, and then delivered to the washer's outer tub. Within four minutes after the wash cycle begins, bleach reaches optimum concentration in the tub.

Maytag finds HYPALON® immune to chlorine bleach at 158° F.

Maytag had a good idea for their All-Fabric automatic washer. Why not design a timed bleach injector to automatically dilute and meter liquid bleach into the wash water? Then the housewife would have to add bleach only once . . . when she loaded the machine. Bleaching would be safe for fabrics, and wouldn't destroy the optical brighteners in detergents.

But there was a problem. To do this, they'd need flexible hose and tubing that could safely handle chlorine-type liquid bleaches. Maytag engineers tested hoses of several materials in 5¼% hypochlorite solution at 158° F. All hoses except one suffered damage within 24 hours. The exception: a hose made of HYPALON, a Du Pont synthetic rubber. It remained unharmed even after a week's testing.

HYPALON was the solution—just as it has been for numerous other appliance design problems. For example, drain hose coated with HYPALON has proved to be color stable and impervious to ozone. On hermetically sealed compressors, HYPALON jacketing for lead-in wire has resisted temperatures to 350° F. To see how HYPALON can serve you, just write for a copy of our booklet outlining properties and performance. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MM-1, Wilmington 98, Delaware.

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SYNTHETIC RUBBER
NEOPRENE HYPALON® VITON® ADIPRENE®

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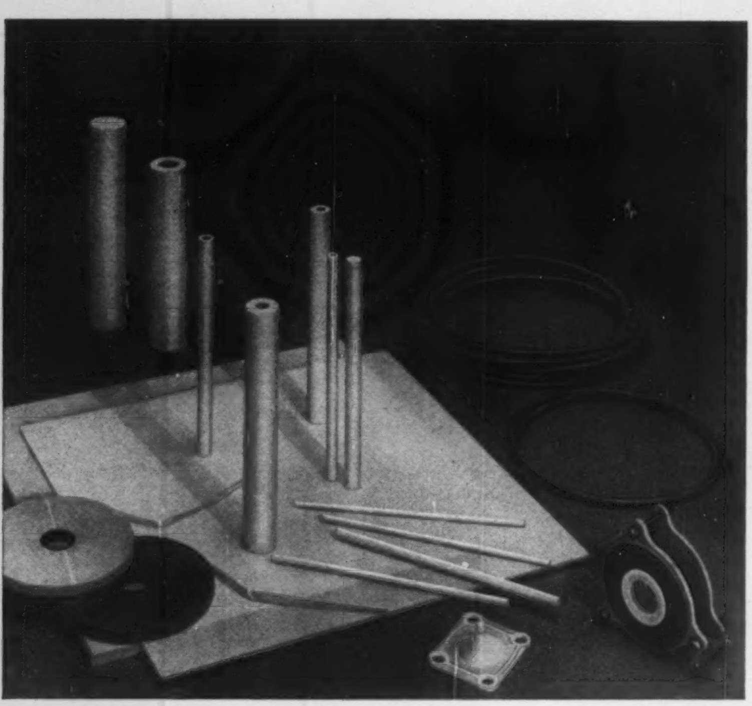

Standard forms or specialized parts, R/M supplies them all in production quantities — according to *your* schedule. New bondable R/M "Teflon" extends the design horizons for this remarkable material, without degrading its other properties. Ask about it.

For design assistance, for production certainty... CALL R/M FOR TEFLON*

No need to restate the unique combination of electrical, chemical and physical properties of "Teflon." You *know* that for many parts calling for high dielectric strength or for resistance to heat and most chemicals, there simply is no substitute.

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On both counts, the answer is R/M. A pioneer in the processing of "Teflon" into sheets, rods, tubes, hose, tape and machined specialties, R/M offers the designer a *complete "Teflon" service* — a service that can help assure efficient production of end products and optimum performance of critical components.

It will pay you to talk "Teflon" with R/M. Call your nearest R/M district office (listed below) or write Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

*Registered trademark for Du Pont fluorocarbon resin

RM

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Shell Chemical Co.

***Fire hazard is eliminated** by solvent-free, 100% solids epoxy coating which does not ignite even when sprayed directly into open flame.*

tanks, and similar vessels, as well as for general maintenance and product finishes requiring good chemical resistance. **Key No. 605**

New appliance enamels applied in one coat

Also announced by Shell Chemical Corp. are two new one-coat appliance enamels that are claimed to be superior to conventional two-coat systems in hardness, gloss, flexibility, detergent resistance, and color retention after overbake.

Although the two enamels have equivalent properties their compositions are almost completely different. One is based on an acrylic resin and the other on a new oil-free alkyd resin. An epoxy resin used with both enamels enables them to perform satisfactorily without a primer, and provides the required adhesion and detergent resistance. Although the coatings were mainly developed for appliances, they are well suited for other applications where white or other light stable enamels are required, such as kitchen cabinets, fluorescent light housings, hospital furniture and showcase fixtures.

Both coating systems are designed for use over steel treated with a phosphate conversion coating. The enamels have a thickness of 1.2 mils after baking, as compared to about 1.7 mils for conventional two-coat systems. Both enamels are extremely hard (they have a pencil hardness of 7H).

Partial immersion tests in a 165 F, 1% detergent solution have shown that the epoxy-alkyd system is slightly superior to a conventional appliance enamel and that the epoxy-

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SIZE	STANDARD HB	*SPECIAL* **HB**	MUSIC WIRE
.1620	219,000 min.	**249,000 min.**	249,000 min.
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.0800	244,000 "	**276,000 "**	282,000 "
.0200	310,000 "	**320,000 "**	350,000 "

—*at savings of up to* 60%

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PAGE is a logical source for other types of manufacturers wire, too. Why not see for yourself what PAGE quality wire can do to improve your product and lower your costs. And if you have an unusual problem requiring a special wire PAGE can help you there, too. The latest example of PAGE leadership is the development of ACCO Aluminized Wire; commercially pure aluminum bonded to a steel core.

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Booklet DH-107A gives complete data on PAGE *Special* HB, including table of tensile strengths, chemical composition, dimensions, finishes, and other information. Write us at Monessen, Pa., for your copy—or for information on any other PAGE wire.

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acrylic system is twice as resistant to detergents as the conventional enamel. In 48-hr ultraviolet light tests, the color and gloss stability of the one-coat enamels are about equivalent to those of a conventional two-coat enamel. After 72-hr exposure, both one-coat enamels showed slightly more yellowing than the two-coat enamel, but retained a superior gloss. **KEY NO. 624**

Inexpensive epoxy-bituminous for good corrosion protection

In addition to the coatings described above, Shell Chemical Corp. also announced a new, low cost epoxy-bituminous system designed for use as an economical, corrosion resistant coating for metal and concrete surfaces. The coating is based on a conventional epoxy resin (Epon 828) and a low viscosity bitumen-base material (Bitumen C) specially prepared to be compatible with epoxies.

The new system is said to have better chemical resistance than conventional epoxy-coal tar systems. It is also claimed to be easier to use, since Bitumen C is a low viscosity material even before adding solvents and does not have to be melted.

Because of its good viscosity properties, the coating can be applied with a higher solids content than a conventional coat tar pitch with epoxy modifier. Thus, the new coating can be applied in thicker films per coat—up to 15 mils in a single coating on vertical surfaces without sagging or pinholing.

The new coating is particularly recommended as an internal and/or external pipe coating, as a coating for off-shore drilling rigs, and for service in areas subject to corrosive fumes and spillage. Because of its good adhesion, toughness and water resistance, it is also recommended for exterior and interior concrete walls below ground level, for silos, and for hopper cars and other railroad rolling stock. **KEY NO. 625**

Two epoxy resins for fluidized bed coatings

Union Carbide Plastics Co., 30 E. 42nd St., New York 17, is now offering two solid epoxy resins, ERRB-0100 and EKRA-2131, which when used together in fluidized bed coatings provide a good combination of mechanical and heat resistance

For more information, circle No. 446 ➤

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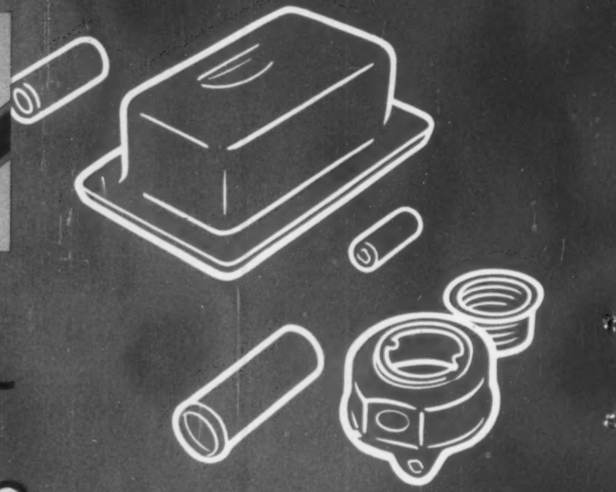
Scovill Manufacturing Company, Mill Products Division, 99 Mill St., Waterbury 20, Conn. Phone PLaza 4-1171.

2SC59



SCOVILL

has a word for the wise aluminum fabricator

THE WORD IS . . . *Truspec*®

THE WELL-BEHAVED ALUMINUM SHEET

Aluminum is not new to Scovill. We were one of the very first mills in the country to start processing this new metal when it became commercially available in the late 1880's. But commercial Aluminum Sheet produced to the same closely controlled specifications Scovill established for Brass Strip was a NEW IDEA when we introduced TRUSPEC Aluminum.

Fabricators have long wanted Aluminum like this . . . because it can so effectively help them control such common problems as "earing" and "orange peel" effect . . . because it can reduce time-consuming adjustments and promote longer tool life . . . because Scovill has made available long-length coils (up to 100 lbs. per inch of width) and the sheet itself is remarkably uniform in gauge, from side to side and end to end.

Scovill believes the customer now gets what he wants . . . in TRUSPEC Aluminum Sheet identified by this Trademark.

it PAYS to specify...

BRASS • COPPER • ALUMINUM
MILL PRODUCTS
identified by this trademark

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MADE IN U.S.A. TO THE STANDARDS OF AMERICAN INDUSTRY ★★★★★★★

made better to bring out the BEST in your products

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3SC59

properties. ERRB-0100 is a highly epoxidized (low epoxide equivalent) resin designed to provide rigidity and heat resistance. On the other hand, EKRA-2131 resin has a much higher epoxide equivalent and imparts greater flexibility and impact resistance. The properties of the two resins can be varied to produce the degree of rigidity, flexibility, impact and heat resistance required. **KEY NO. 626**

Alkyd resin air dries fast

A versatile, pure short-oil soya alkyd designed for very fast air-dry or force-dry applications is now available from Archer-Daniels-Midland Co., 700 Investors Bldg., Minneapolis 2. Heretofore, a styrenated alkyd or alkyd copolymer had to be used, at the expense of lowered color retention and mar and solvent resistance, to obtain fast drying prop-

Large closed-die forgings—This large closed impression die forging hammer is now in operation at Ladish Co., 5481 S. Packard Ave., Cudahy, Wis. turning out ferrous and nonferrous forgings weighing over 22,000 lb. The closed impression die forging process is said to substantially improve metal strength-weight ratios by compressing and densifying the material. **KEY NO. 623**

For more information, turn to Reader Service card, circle No. 322

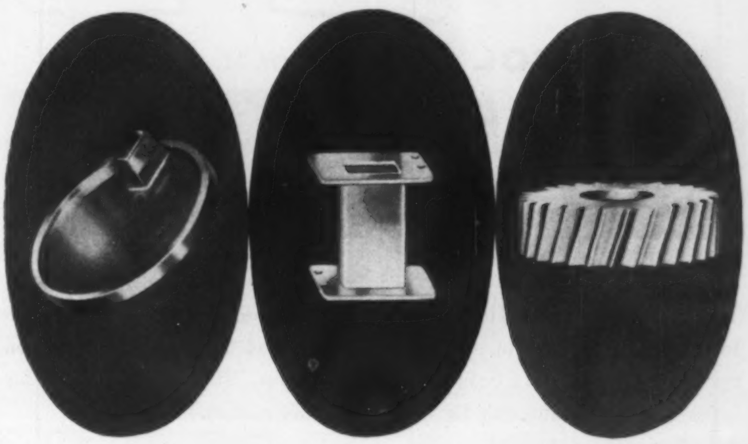
WANTED: a new use for a new material ZEVESCAL®

Zevescal, a patented wear-resistant alloy, is producing exceptional wear life in cast parts for equipment such as

SCREW CONVEYORS • FRIT CRUSHERS
IMPACT CRUSHERS • SAND SLINGERS
SHOTBLAST MACHINES • BALL MILLS
HYDRAULIC DREDGES • GRINDERS
• HAMMER MILLS

Tell us how you think you could use ZEVESCAL for applications requiring optimum resistance to wear. We will be glad to send a sample for testing in your own product or process.

CALUMET STEEL CASTINGS CORPORATION
Manufacturers of Carbon, Alloy, Heat, Wear and Corrosion-Resistant Electric Furnace Steel Castings
1606 SUMMER STREET • HAMMOND, INDIANA



Experience and know-how behind each molded part

Even more important — to you — is its cost and quality. Our extensive 20-year background in the molding of plastics of all types assures you low-cost, high-speed production (with no loss of quality!) regardless of the size or quantity of your plastic needs. Your inquiries or problems will receive our prompt attention.

custom molders of the unusual

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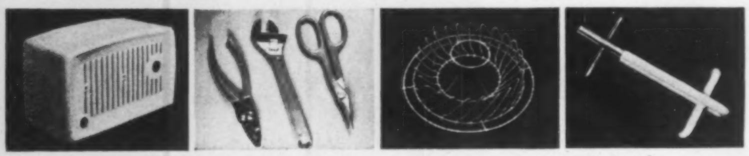
60 WATER ST. ATTLEBORO, MASS. Tel. AT. 1-4040 • N. Y. OFFICE: 303 FIFTH AVENUE Tel. MU. 6-0327

For more information, turn to Reader Service card, circle No. 387

COATING PROBLEM ?

REYNOSOL* *SOLVED THESE PROBLEMS*



* Reg. Trademark

There's a special Reynosol formulation for your coating problem. And if it's steel you're coating you'll be interested in the extra benefits that only Reynosol can offer you.

What are they? Greater resistance to temperature . . . truest color control . . . greater tensile strength . . . lower total cost.

Reynosol coatings are as functional as they are decorative . . . as economical as they are reliable. Let Reynolds Chemical creative staff tackle your finishing problem — show you how Reynosol can finish your problem! They'll come up with exactly the answer — and the price — you've been hoping for. Write or phone today for full information.

REYNOLDS CAN COAT IT — IF ANYONE CAN!

REYNOLDS CHEMICAL PRODUCTS COMPANY

Whitmore Lake, Michigan • Phone: HIckory 9-9361
DIVISION OF STUBNITZ GREENE CORP.

For more information, turn to Reader Service card, circle No. 450

erties. The new alkyd resin (Aroplax 6006-X-50) provides fast air drying with no sacrifice in mechanical properties or chemical resistance.

The resin permits coatings to dry tack-free in 5 to 10 min, and develops good through hardness overnight. Thus, the coating is expected to permit faster finishing schedules. Recoating and touch-up can be done in early stages of cure before oxidation starts or else after sufficient oxidation has taken place. In general, recoating can be done within 8 hr, or after 72 hr of application. The time that must be allowed before recoating depends on a number of factors, such as amount and type of drier, solvent and antioxidant used, film thickness and temperature.

Other advantages claimed for the new resin are high solids at spray viscosity, and good hardness, durability and salt spray resistance. The resin is compatible with varying oil-length alkyd resins and other film formers, and has good tolerance for aliphatic solvents. It is particularly recommended for implements, machinery cabinets, hardware and automotive refinishing. **KEY NO. 609**

Phenolic-Graphite Withstands 5000 F

Newly developed phenolic-impregnated graphite fabrics show promise for use in missiles and other applications requiring exceptional heat resistance. In a laboratory ablation test, it took more than 10 min for a 5000 F oxyacetylene flame to burn through a 6-in. square by ¼-in. thick sample of the material—equivalent to a burn-through rate of less than 0.0005 ips.

Typical burn-through rates for other materials are: 0.0017 ips for phenolic-impregnated high silica glass; 0.002 to 0.003 for phenolic-impregnated felted asbestos and

AWARDS COMPETITION—Entries for the 4th annual Awards Competition for the Best Use of Materials in Product Design are due Feb. 1, 1960. See p 138 for full details.

To obtain even radiographic density from edge to edge, the rods were cradled in a block of aluminum.

Radiographs reveal air bubbles in the ceramic rods.

The case of the breaking ceramic rods

THESE RODS support an electronic element in an intricate traveling-wave tube. They must withstand high temperatures—high vacuum.

Unaccountably, in the early development of traveling-wave tubes, some rods would break. Also some tubes were difficult to pump down to high vacuum.

To find the reasons, Sperry Gyroscope Company turned to radiography.

The radiographer employed a filter device to obtain even density from edge to edge of the radiographic image of the rods. The defective rods were found to contain tiny air bubbles which expanded when the tube was heated and caused the breakage. They also were the cause of the difficulty in degassing the tubes.

In the inspection of assemblies, of castings, of welds, radiography provides a reliable means of examining internal conditions and making sure that only high-quality products are delivered. Often it suggests ways of improving manufacturing methods and cutting costs.

Would you like to learn how radiography can work profitably for you? Talk it over with an x-ray dealer or write for a Kodak technical representative to call.

Read what Kodak Industrial X-ray Film, Type AA, does for you:

... Speeds up radiographic examinations.

... Gives high radiographic contrast, increased detail and easy readability at all energy ranges.

... Provides excellent uniformity.

... Reduces the possibility of pressure desensitization under shop conditions.

X-ray Division

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

Kodak

For more information, turn to Reader Service card, circle No. 325

Spotlighting Reliability!

MICRO-PROCESSED
I-S BERYLLIUM-COPPER
SPRINGS

Exclusive Design Advantages

I-S micro-processed beryllium copper springs, designed into control devices, relays, circuit breakers, etc., result in improved performance and lower cost. Their high degree of uniformity eliminates the necessity of hand adjustment during assembly and is your guarantee of uniform performance.

Important Electrical Advantages

I-S micro-processed beryllium copper springs receive laboratory-proven heat treatment, therefore they can operate at higher temperatures and carry more current with less temperature rise.

THE *Ideal* SPRING MATERIAL

Beryllium copper is an ideal spring material because of its natural inherent characteristics. It is non-magnetic, has the corrosion resistance of pure copper, high electrical conductivity, high wear resistance and a high endurance life. The temperature used to develop spring temper also serves to relieve internal stresses remaining from cold work. The ability to conform to jigs and holding fixtures during heat-treatment makes it particularly well suited for our specially designed, patented machines. The wire is placed upon the mandrel in an exacting manner, strictly in accordance with the engineered design. The springs are set to this design by heat-treatment while they are still on the mandrel. There is no spring back upon removal from the mandrel with the result that the springs are uniform, stable and free from drift.

CALL OR WRITE FOR THE I-S CATALOG covering in detail compression springs, flat springs, strip springs, contact rings, contact strips and screw machine products.

IN SWEET'S PRODUCT DESIGN FILE

INSTRUMENT SPECIALTIES CO • INC

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I-S
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224 BERGEN BLVD. LITTLE FALLS, N. J.

Telephone: CLifford 6-3500

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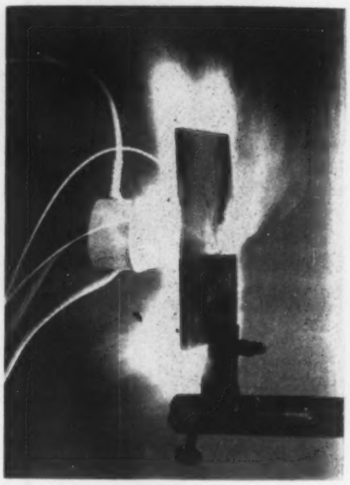


***5000 F flame** takes more than 10 min to burn through a ¼-in. thick specimen of phenolic-impregnated graphite fabric.*

0.004 for phenolic-impregnated glass cloth laminates.

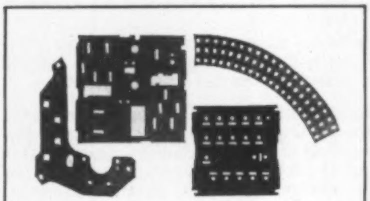
The phenolic-impregnated graphite fabric was developed by Continental-Diamond Fibre Corp., Newark, Del. It is called N-104-84-2. Continental-Diamond says it will supply samples of the material to companies that have a "DX-A2" ballistic missile program priority. The samples are available in two forms: laminated 6 in. squares in thicknesses up to ½ in.; and 3-in. dia cylindrical moldings made from macerated impregnated fabric in depths up to 2 in.

Graphite fibers, introduced in the spring of 1959 (M/DE, May '59, p 149), have a crystalline structure similar to that of conventional manufactured graphite. Thus the fibers combine the flexibility of textiles with the high temperature strength, chemical inertness, high electrical and thermal conductivity, and self-lubricating characteristics of graphite. **KEY NO. 610**

Two More Materials for High Temperatures

Raytheon Co., Plastics Div., Box 25, Great Rd., Maynard, Mass. has developed two heat resistant materials for missiles and high tempera-

LET SPAULDING GIVE YOU A HAND WITH YOUR TERMINAL BOARD PROBLEMS



Specially trained Sales Engineers . . . a broad choice of basic materials . . . extensive fabricating facilities . . . 85 years of experience. These Spaulding assets are at your disposal for terminal board material selection, design or production.

Spaulding's variety of basic materials provide unique combinations of properties to solve any problem in application. They have extremely high dielectric strength, low cold flow, good staking qualities, as well as toughness, chemical inertness, moisture resistance and dimensional stability. They are available fabricated to your exact specifications in completely uniform parts and in basic form such as sheets, rods and tubes.

Contact Spaulding. A Spaulding Sales Engineer can be at your office in a matter of hours with complete data on basic materials, fabricating service and engineering assistance.

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NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION
NEMA
MEMBER

SPAULDING FIBRE COMPANY, INC.

335 WHEELER STREET • TONAWANDA, NEW YORK

For more information, turn to Reader Service Card, circle No. 404

Graphite Specialties
CORPORATION

Solves
difficult
problems with
GRAPHITE

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MECHANICAL USES
SPACECRAFT
ATOMIC ENERGY
METALLURGICAL
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Graphite Specialties
CORPORATION
64th Street and Pine Avenue
Niagara Falls, New York

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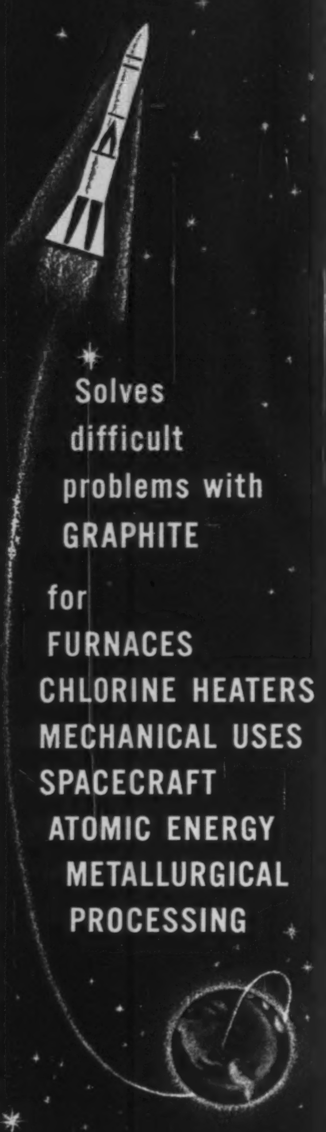

ture applications. One is an oriented graphite called Pyrographite (see phenolic-graphite laminate mentioned above), and the other is a plastics resin. Both materials are still in the development stage.

Plastics resin

Raytheon says its plastics resin, a tri-ester polymer, is being evaluated as an ablative coating and as an electrical insulating material in the temperature range 500 to 8000 F. Tests to date show the resin resists the high pressures and temperatures of a Mach 4 blast environment. Limited property data show the resin has a specific gravity of 1.3 to 1.8, a thermal conductivity of 1.5 Btu/hr/sq ft/°F/in. at 500 F, and a coefficient of thermal expansion (reinforced) of 1 to 4 x 10^6 per °F.

KEY NO. 611

Oriented graphite

Raytheon says its Pyrographite will solve the high heat problems in missiles and nuclear reactors. The material is described as strong at high temperatures, erosion resistant and impervious to gases and liquids. It is said to distribute heat along its surface, thus preventing heat build-up in unwanted areas.

The company says it has developed a practical process for making the material. It involves the manufacture of crystals from the deposits of carbonaceous vapor at temperatures above 3500 F.

The graphite material has undergone preliminary tests in rocket nose cones in projects sponsored by the Navy Bureau of Ordnance.

More detailed information on the properties and uses of Pyrographite will be given in the February issue.

KEY NO. 612

Refining Technique May Cut Price of Titanium

A new electrolytic method for refining titanium metal may some day lead to lower cost titanium sheet and bar stock. Current price

SOURCES of most engineering materials can be found in the third edition of M/DE's *Materials Selector* reference issue, published in October. Properties of all materials are also given.

Details, ideas, sources for all fastening needs . . .

FASTENERS Handbook

by JULIUS SOLED, P.E.
Consulting Engineer

1957
448 pages
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NEW! OVER 900 ILLUSTRATIONS!

FASTENERS HANDBOOK provides ready, up-to-date answers to fastening problems in all fields. Its pertinent data, hundreds of illustrations, and full page descriptions supply you with detailed information on currently available fasteners.

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- Brings to your attention the many cost-saving features of available, less-known fasteners.
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FASTENERS HANDBOOK greatly facilitates the review of available information, the making of a valid selection, and contacting the sources of supply. It can be used by design engineers, patent attorneys, sales personnel, fastener distributors and jobbers—in fact, anyone who needs solid information on fasteners available for mechanical assembly.

Everything in fasteners

Rivets, Inserts, Screws, Bolts, Studs, Nuts, Washers, Retaining Rings, Pins, Nails, Metal Stitching, Quick Release Fasteners, Masonry Anchoring Devices, Hose Clamps, Manufacturers Directory.

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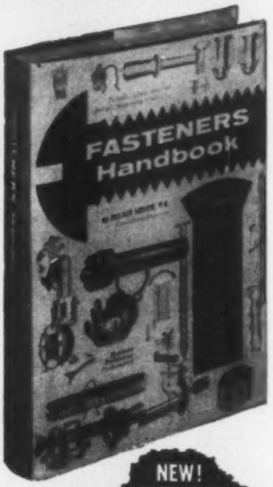

FOR GREATER EYE APPEAL

AND MARKETABILITY . . .

Build Your Product With

ZINC DIE CASTINGS

Out of the myriad materials available, this manufacturer used zinc die castings in their wall can opener because they:

- FINISH WELL
- WEAR WELL
- ARE LOW IN COST

The Rival Manufacturing Co.'s, "Can-O-Mat" and its four components die cast in zinc at right.

These advantages enabled the manufacturer to market the opener successfully in a highly competitive field where style, flawless finish and moderate cost are prime requisites.

Industry's preference for zinc as a base for die castings is indicated by the fact that, normally, zinc alloys account for about two-thirds by weight of all die castings used annually. This is due to ease of casting and finishing, excellent physical properties, close dimensional tolerances and the wide variety of beautiful finishes which can only be attained with die castings based on 99.99+% zinc.

Die Casting is the Process . . . Zinc the Metal . . .

BUNKER HILL 99.99+% ZINC

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ZN-147

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A leading manufacturer of x-ray film needed a wrapping paper that would be 1) opaque; 2) free of trace radioactivity commonly present in paper; and 3) of uniform thinness for ease of packing and dispensing film. Knowlton came up with a duplex paper — pure white on one side, pure black on the other — which consistently meets all three specifications.

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For more information, circle No. 410

is about $9 per lb.

The method uses titanium carbide as the starting material instead of the titanium tetrachloride now used in fused-salt bath methods. The carbide contains about three times as much titanium as the tetrachloride. Both materials sell for about the same price.

How method works

The method, still under development, was devised by a team of research men at Norton Co., Worcester 6, Mass. It uses titanium carbide as the anode of an electrolytic cell. The tiny titanium crystals obtained are said to have a purity of 99.6%, and can be melted into ingots or fabricated into sheet and bar by powder metallurgy techniques. **KEY NO. 622**

Background

The Bureau of Mines began research on the refining of titanium in 1938 and during the period from 1941 to 1952 developed the Kroll process which is now used commercially for the production of titanium metal (1958 production was 4500 tons).

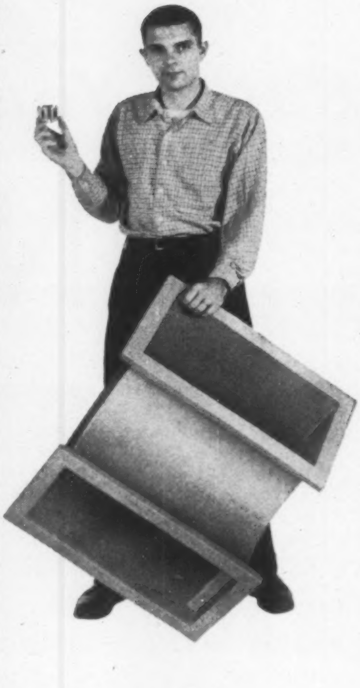
A study of the electrochemical approach for producing titanium was undertaken in 1952, and a technique for refining off-grade sponge and scrap in a fused-salt bath was developed in 1957. The cells in the bath were heated externally and they lasted for only a short time because of scaling. A recent improvement in the Bureau's fused-salt bath process, which is described in Bureau of Mines Report No. 5494, uses internal rather than external heating. Advantages: more effective heat utilization, simplified cell design, and prolonged cell life. **KEY NO. 613**

Other News . . .

Metals

▶ A magnetic alloy with closely controlled and uniform properties has been developed by Magnetic Metals Co., Hayes Ave. at 21st St., Camden, N. J. The alloy is called Super Squaremu 79. 614

▶ Kaiser Aluminum & Chemical Corp., Kaiser Bldg., 1924 Broadway, Oakland 12, Calif. says it can supply



Aluminum wave guide components, large and small, are cast smooth, sound and accurate by the unusual foundry methods of Morris Bean & Company, Yellow Springs 5, Ohio

BEAN

aluminum
magnesium
ductile iron
foundries

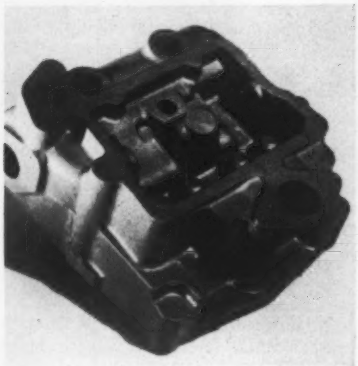
For more information, circle No. 376

PRODUCT-DESIGN BRIEFS FROM DUREZ

- Smooth surfaces in metal castings
- Plastic in luggage pods
- Fast facts on phenolics

Inside story

In an engine block such as this one, smoothness of the inner surfaces is a high-priority design problem. Any obstruction or undue roughness in the channels is likely to impede the flow of coolant through the block.

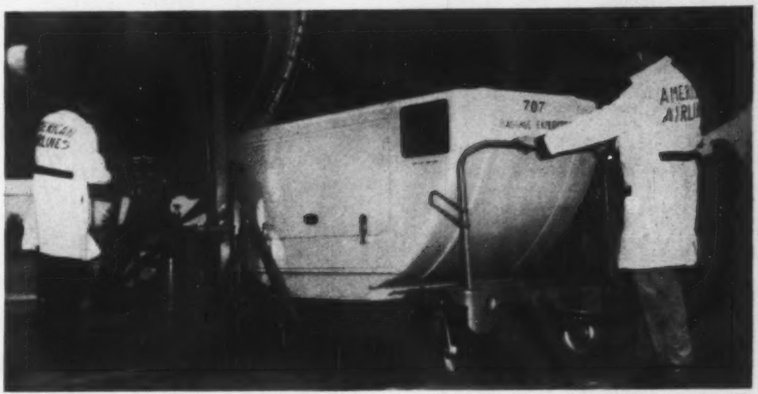


To solve the problem, more and more foundrymen are switching to a method of making castings that gives smooth, clean inner surfaces every time: shell cores.

They're getting more than smoothness. The close tolerances possible with shell cores permit holding section thickness uniform throughout the piece, and from piece to piece. In an engine block, that means better heat transfer.

Finally, most castings made with shell molds and cores need only a bare minimum of machining. That saves money.

Want to know how these better castings are made with the help of Durez foundry resins? Check the coupon and let us send you the new "Durez Guide to Shell Molding."



AMERICAN AIRLINES

It expedites

This pod shrinks time.

For people who have alighted from a jet airliner, it shortens the wait at the luggage checkout.

For the airline, it telescopes flight schedules by cutting ground time to the necessary minimum. For the men who use it to load or unload 35 suitcases at a crack, it takes much of the "lug" out of luggage.

It has to be strong, light in weight, safe. That's why it is made of Hetron® glass-reinforced polyester. Not only does Hetron match and excel the strength characteristics of other reinforced plastics; it is also inherently and *permanently* self-extinguishing. The safety is chemically locked in to stay—not obtained by dilution with additives.

Many great ideas like this one are taking shape in Hetron. They include 65-foot radomes, factory skylights, large boat hulls, outboard motor shrouds, chemical ducts and blowers, transformer housings, heavy-duty switch-gear components.

If you'd like to know more about this versatile, safe material—and who can mold it into shapes for you—check the coupon for the designer's Hetron data file.

At your finger tips

Here's the quickest way we know to compare one phenolic molding material with another. Just send for the new 16-page booklet "Facts on Phenolics." It groups the most popular Durez materials by types (general-purpose, impact, heat-resistant, electrical, etc.). It lists properties of the molding compounds and of molded specimens. It tells which MIL specs a compound is designed to meet. All you do is check the coupon to get a copy free.

For more information on Durez materials mentioned above, check here:

☐ Data file on Hetron, including list of fabricators
☐ "Durez Guide to Shell Molding" (36-page bulletin)
☐ "Facts on phenolics" (16-page booklet)

Clip and mail to us with your name, title, company address. (*When requesting samples, please use business letterhead.*)

DUREZ PLASTICS DIVISION
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For more information, turn to Reader Service card, circle No. 420

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HIGH FREQUENCY INDUCTION HEATING UNITS

BRAZING
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ANNEALING

Lepel induction heating equipment represents the most advanced thought in the field of electronics . . . the most practical and efficient source of heat developed for numerous industrial applications.

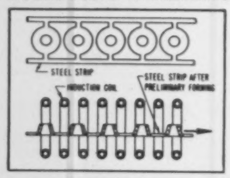
You are invited to send samples of work with specifications. Our engineers will process and return the completed job with full data and recommendations without cost or obligations.

TYPICAL INDUCTION HEATING APPLICATIONS

PLASTIC COATING OF TOOL HANDLES

A production line operation for coating handles of tools at Whitney Metal Tool Co., Rockford, Ill. uses induction heating with excellent results. The handles only are heated by induction to the desired temperature then dipped into a vinyl chloride base coating material for a short period depending upon the thickness of coating desired. The plastic coating formed on the handles is then cured by immersion in a carbo-wax bath.

FORMING OF METAL STRIP FACILITATED BY PROGRESSIVE ANNEALING



Metal forming operations which require intermediate anneals to restore ductility can be facilitated by induction annealing the strip progressively. Diagram illustrates this procedure for partially formed thin austenitic stainless steel strip. The induction annealing operation is scheduled in the production line between two press operations. Metal strip and wire of other materials are also induction annealed in this manner.

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.

WRITE FOR THE NEW LEPEL CATALOG

All Lepel equipment is certified to comply with the requirements of the F C C

LEPEL HIGH FREQUENCY LABORATORIES, INC.
55th STREET and 37th AVENUE, WOODSIDE 77, N. Y.

For more information, circle No. 457

What's new IN MATERIALS

aluminum impact extrusion stock at substantial savings as a result of a new process for continuous casting aluminum slabs. The stock is being cast in thicknesses ranging from ⅝ to 2 in., in widths from 6 to 12 in., and in lengths from 12 to 240 in. 615

Plastics

▸ A TFE tape provides leakproof threaded pipe joints for unplasticized PVC, stainless steel, aluminum and other corrosion resistant piping. The tape is marketed by Tube Turns Plastics, Inc., 2929 Magazine St., Louisville 11, Ky. 616

▸ Enjay Co., Inc., 15 W. 51st St., New York 19 has introduced a new line of butoxy resins for use in reinforced plastics parts such as containers, trays, decorative panels and other types of fiberglass and paper laminates. The resins, called Buton, will be available this spring. The company has also introduced a Buton resin for use in paint. 617

Other nonmetallics

▸ Monsanto Chemical Co.'s Research & Engineering Div., 800 N. Lindbergh Blvd., St. Louis 66 is supplying samples of micro-fine aluminum, titanium and zirconium oxide for use as reinforcing agents in plastics, metals and rubber. 618

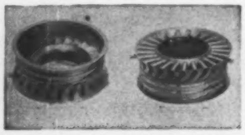
▸ A silicone fluid for sealing electrical connections to prevent arcing, flash-over and short circuits is available from Dow Corning Corp., Midland, Mich. The fluid is packaged in a collapsible metal tube to permit easy use on hard-to-get-at electrical connections. 619

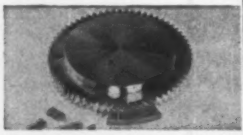
Finishes

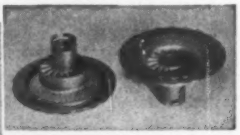
▸ A new type of anode for zinc plating is said to provide approximately 20% more surface area for plating than standard ball anodes. Called "Roll-Top," the anode is cast in a modified oval form. It is available from Allied Research Products, Inc., 4004 E. Monument St., Baltimore 5, Md. 620

Joining materials

▸ Disks, washers and special shapes made of nickel and other metals clad on one or both sides with solder are designed for use in automatic joining operations. The solder-clad parts are available from Alloys Unlimited, Inc., 21-01 43rd Ave., Long Island City, N. Y. 621



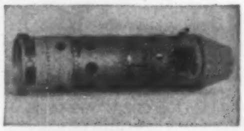


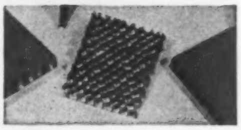


We Furnace Braze Stainless Alloys

To eliminate problems of distortion, stress, oxidation, and porous welds

The advantages of stainless alloy brazing in dry hydrogen or vacuum environment furnaces are many. And the use of brazing for high-temperature service parts is growing just as fast as potential users learn to design for it. We offer technical design assistance to further the acceptance of this modern joining technique. Ten years of pioneering this field, plus operating three stainless processing plants, plus manufacturing our own Nicrobraz® brazing alloys, fully qualifies us to give initial guidance to your design crew in planning brazed stainless components. Call TWinbrook 3-3800 in Detroit, or write to find out how we might help you.

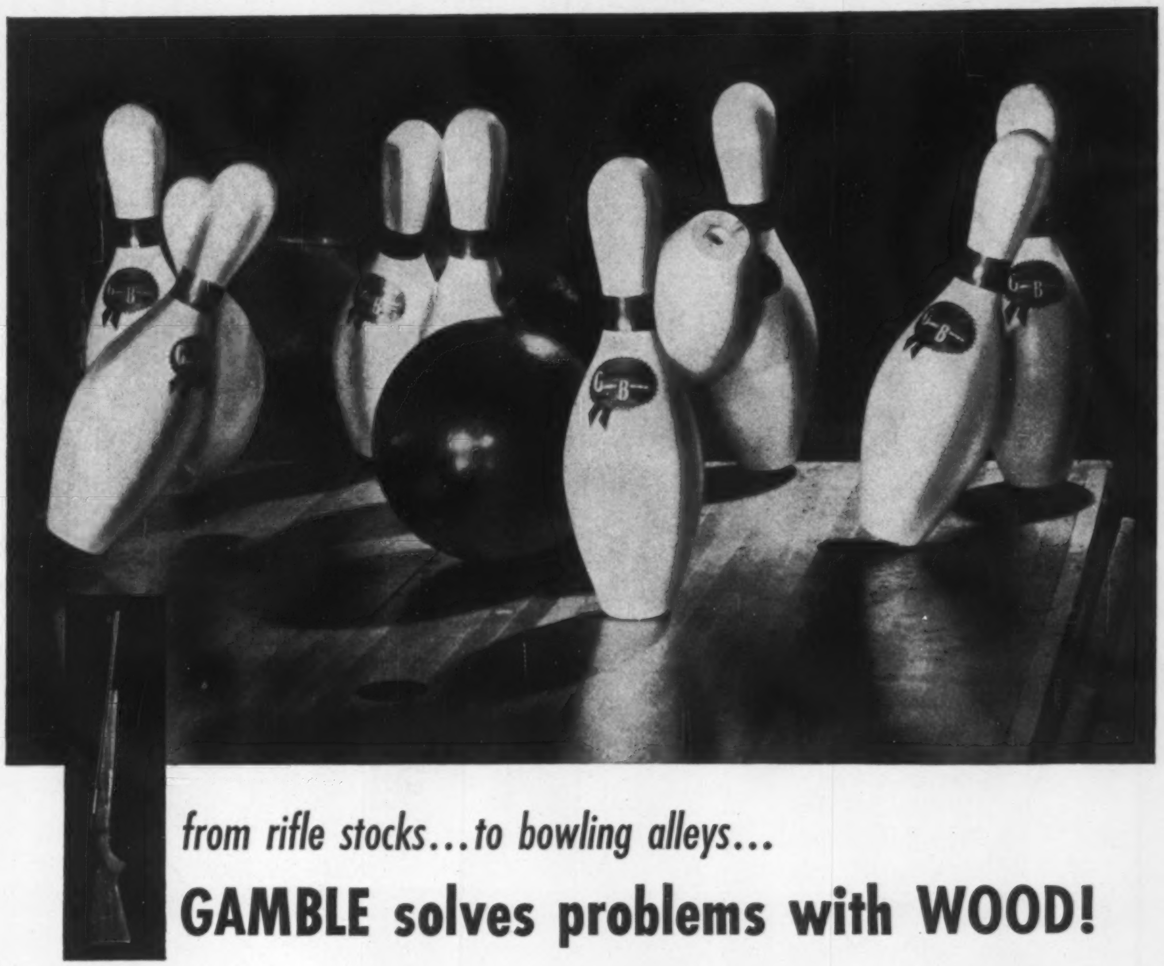




STAINLESS PROCESSING DIVISION
WALL COLMONOY CORPORATION
19345 John R Street • Detroit 3, Michigan

There are Wall Colmonoy furnace plants in Detroit, Michigan; Morrisville, Pennsylvania; and Montebello, California

For more information, turn to Reader Service card, circle No. 358



from rifle stocks...to bowling alleys...

GAMBLE solves problems with WOOD!

Marksmen found that the slightest swelling or shrinking of their rifle stocks reduced firing accuracy. To solve the problem, a custom gunstock manufacturer turned to Gamble Brothers. Result: a laminated gunstock blank with greater dimensional stability, less tendency to warp, greater strength, and freedom from internal stresses.

To the pioneer producer of laminated pins — Gamble Brothers — came another problem from the bowling industry: need for ball return upsweeps and downsweeps on which the ball would not skid, then stop halfway back. Result: a laminated track which is stronger, takes less wood — and with proper friction factor for conveying ball back to bowler.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers — a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

Solving Problems in Wood

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GUARANTEED BOND

GB

GAMBLE BROTHERS, INC.

4627 Allmond Avenue, Louisville, Kentucky

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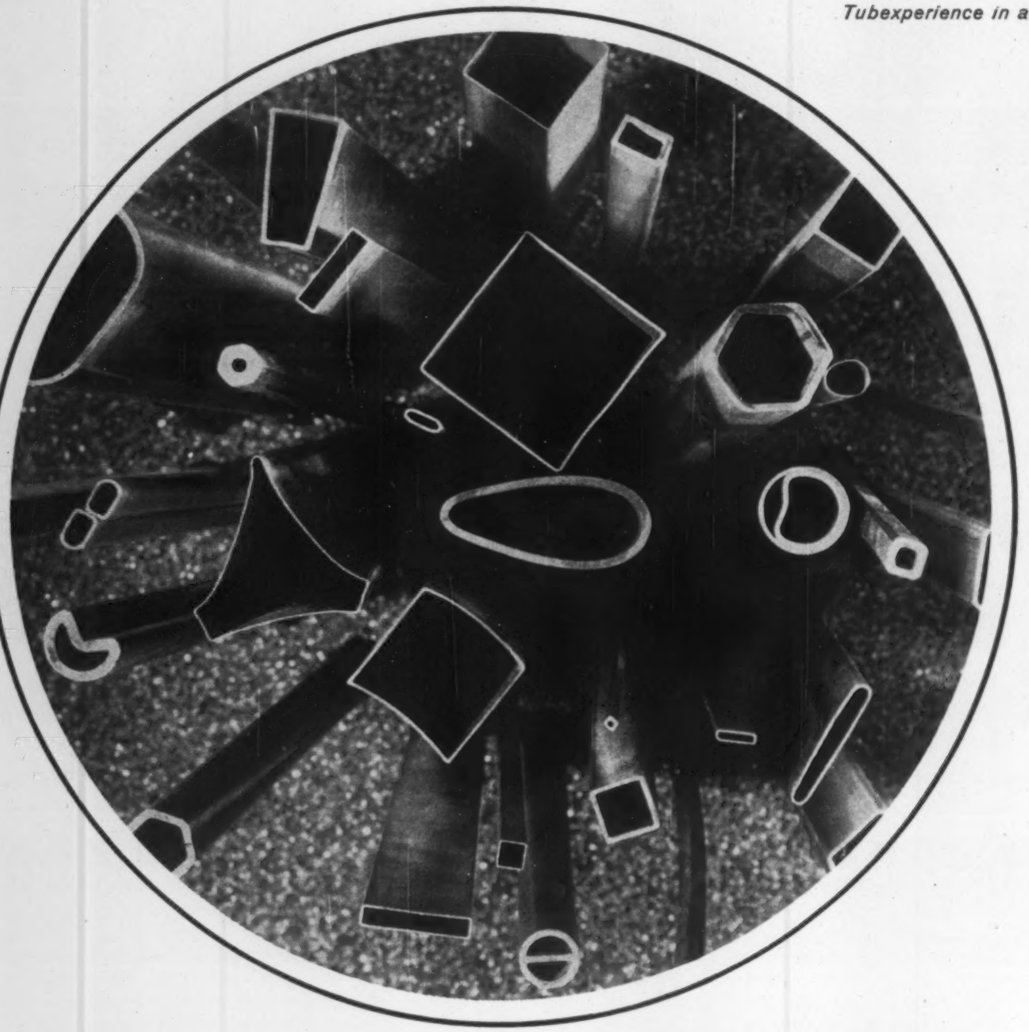
Tubexperience in action



Tubing shaped to New Ideas

Many people think of tubing only in its most common form—round. As design engineers and buyers, you know it can be produced economically in a large variety of unusual shapes. But have you ever seen the particular shapes illustrated on this page? They are samples from production runs formed to extremely close tolerances to satisfy specific design requirements. End uses include Bourdon springs, surgical instruments, batons, aircraft structural parts, gun drill shanks, radar screens, door latches, electrical equipment, antennas, golf club shafts, fishing rods and bushings. However, we don't know where all the different shapes are used, or why they are required. But our ability to form them saves manufacturers in many industries considerable time and money in the fabrication of their products.

Superior regularly produces shaped tubing in many analyses of stainless steel, carbon and alloy steels, nickel and nickel alloys, and glass sealing alloys. Also in titanium and beryllium copper. Shaped tubing is generally supplied in the as-formed temper (annealed before shaping), but many special tempers can be supplied.

We can probably supply your requirements at low cost, in good time. Data Memorandum No. 17 gives full details about Superior Shaped Tubing. Write for a copy today. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Superior Tube
The big name in small tubing
NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

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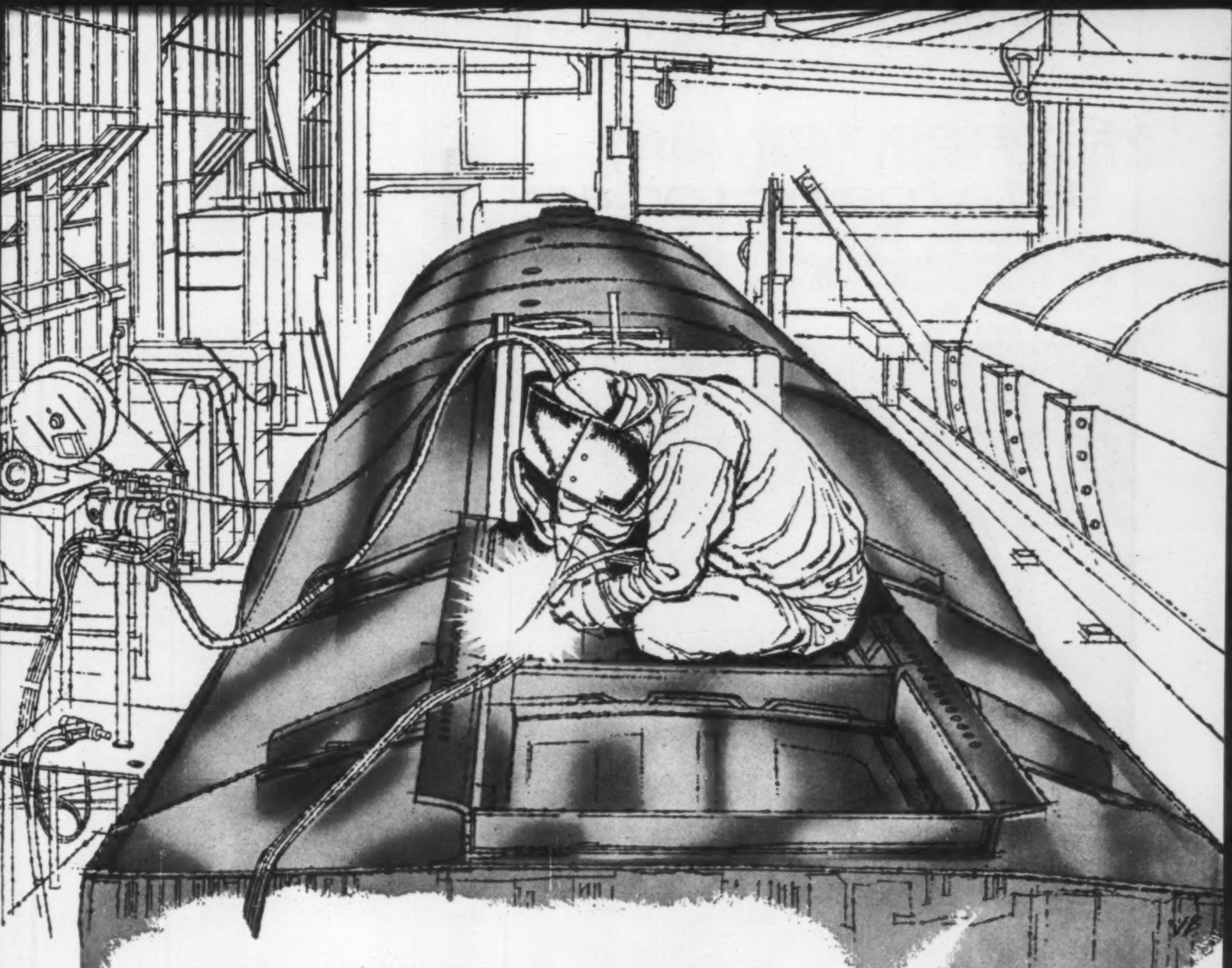


Formula for Success

The formulation of a stainless steel alloy requires as much precision as any chemical compound. All the care exercised in the selection of a particular alloy can be nullified by variations in the analysis specified.

During fabrication, for example, slight differences in chromium-nickel: carbon ratios can cause changes in microstructure which lead to early failure.

That's why it is safer to specify J&L Consistent Quality Stainless Steel. J&L leads the industry in melt shop standards for stainless steel—the point where quality starts, **and longer service life begins.**

J&L

STAINLESS

SHEET • STRIP • BAR • WIRE

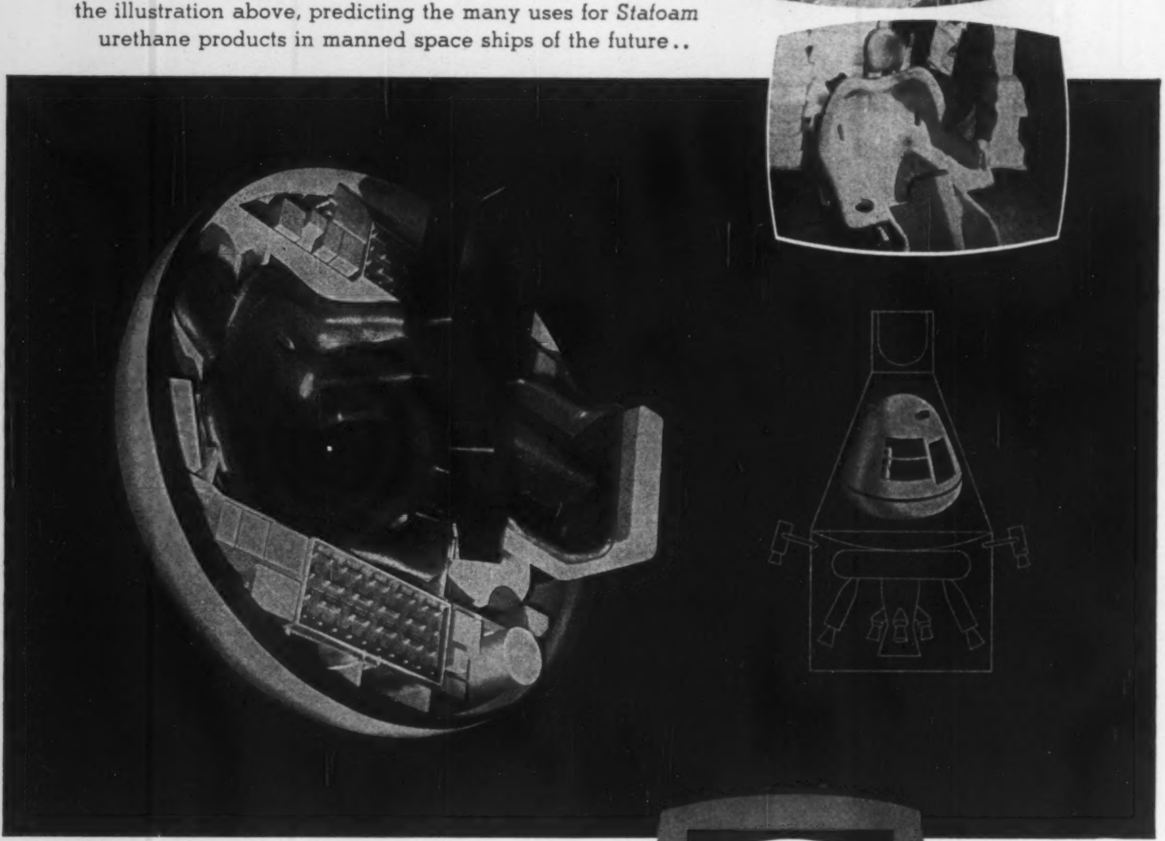
Plants and Service Centers:
Los Angeles • Kenilworth (N. J.) • Youngstown • Louisville (Ohio) • Indianapolis • Detroit

For more information, circle No. 426

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Box 4606, Detroit 34

Space for Stafoam today!

A few months ago we published an advertisement featuring the illustration above, predicting the many uses for *Stafoam* urethane products in manned space ships of the future..



Actual photograph of prototype manned capsule, a major element of maneuverable satellite for rendezvous in space, under development by the Astro Systems Research Laboratories, Norair, Division of Northrop Corp.

Today, a prototype man-carrying space capsule *is* using *Stafoam* cushioning to provide shock endurance and comfort for its human cargo. *Today,* men and intricate devices are insulated against new temperature dimensions with rigid *Stafoam. Today,* delicate instruments and components are potted in *Stafoam Polypot. Today,* precise mechanical parts are cast with *Stafoam Daycollan.*

Today practical applications for *Stafoam* urethanes are as infinite as space itself. The successful projects listed below have proven to men of vision that there *is* "space for *Stafoam* today."

For a new dimension in material technology, contact the Freedlander R & D Laboratories, American Latex Products Corp., or its branches. Specify product requirements and/or material category.

stafoam
REG. TRADE NAME
by

AMERICAN LATEX PRODUCTS CORP.

3341 West El Segundo Blvd., Hawthorne, California
ORegon 8-5021 OSborne 6-0141

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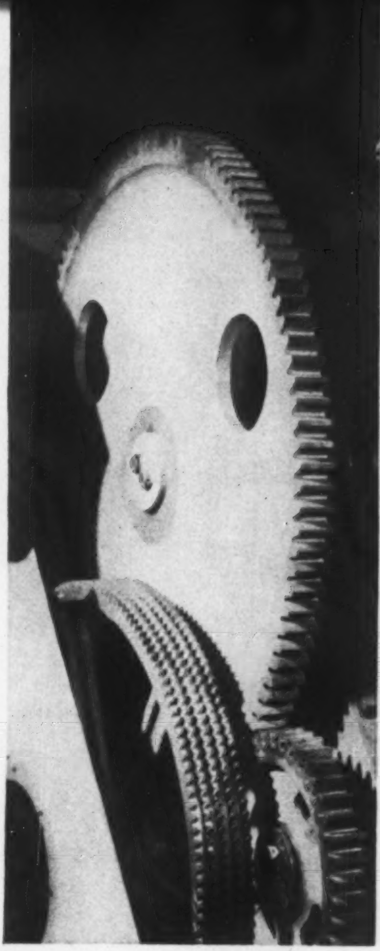
A DIVISION OF THE DAYTON RUBBER CO.
Headquarters for New Ideas

STAFOAM RIGID	STAFOAM FLEXIBLE	POLYRUBBER	POLYPOT	DAYCOLLAN
Thermal insulation	Aircraft & conveyance seating	Personnel shock padding	Instrument potting	Gear, roller bearings, O rings
Acoustic dampening	Commercial cushioning	Instrument & motor mounts	Crystal clear windows & mtrls.	Instrument & control knobs
Foam core construction	Shock padding (high hysterisis)	Elastomer coupling	Control knobs & accessories	Instrument scope boots
Helmets and liners	Clothing insulation & liners	Oxygen hose and masks	Electronic encasing	Airless wheels & tires
Packaging & flotation	Air & liquid filtering	Window and hatch gasketing	Applicable hardware	Applicable hardware

For more information, turn to Reader Service card, circle No. 359

This gear now costs $35.24 less,

THANKS TO BETHLEHEM CIRCULAR FORGINGS



GEAR *installed in hoist mechanism of Koehring Company power shovel.*

EXCELLENT *response to induction hardening? Take a look!*

> *"We are also very pleased with product machining properties, freedom from defects in the tooth area, and excellent response of the forging to heat treatment."*

KOEHRING COMPANY, MILWAUKEE, WISCONSIN
manufacturers of construction equipment

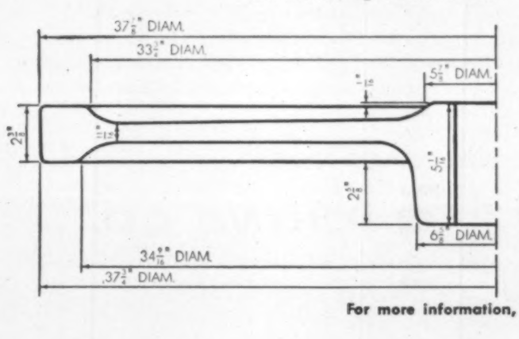
Koehring Co. previously machined this gear from a cast gear blank. Today they machine it from an impression-die steel forging made on Bethlehem's unique Slick Mill. They save $29.24 in first cost, plus $6.00 in machining costs! (Turning, boring, facing, and hobbing teeth.)

Here's how we do it

The answer, of course, lies in Bethlehem's Slick Mill—the only one of its kind in the country. Quick die set-up (only 15 minutes)—quick operation (just one minute to forge and roll a circular product)—low die charges (⅓ to ½ less than conventional impression dies)—and less steel needed (utilizing the principle of forging design, the Slick Mill can produce lighter-weight sections without sacrificing strength) . . . all these add up to important savings. At the same time, the process insures *soundness, excellent grain flow,* and *machinability.*

Bethlehem's Slick Mill saves the Koehring Company $35.24 *per gear.* How much can it save you?

Bethlehem Circular Forgings are available in carbon, alloy, or stainless steels, as well as certain heat-resistant grades. 10 to 48-in. OD. 100 to 2,000 lb. As-rolled, or rough-machined to specifications. Call or write the Bethlehem sales office nearest you for full details.



NOTICE *the thin disc shape on this 395-lb gear blank. A cinch on the Slick Mill!*

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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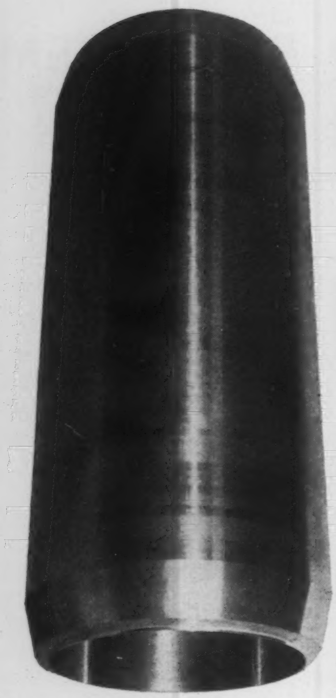
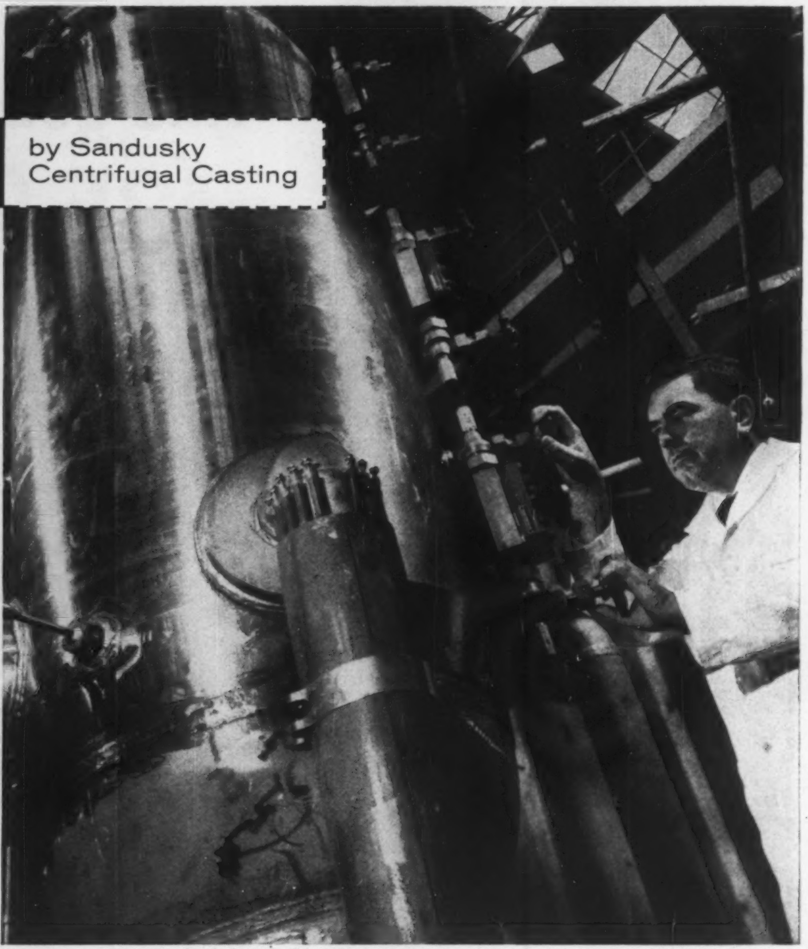
SOLVED: by Sandusky Centrifugal Casting





This photo, showing the Sandusky cylinder welded into position, courtesy of the Lummus Company, New York. New York who fabricated, assembled and tested the completed loop before shipping it to the ETR site in Idaho.

Nuclear Test Loop Uses Sandusky Centrifugal Casting as Pressurizer Cylinder

A Sandusky Centrifugal Casting is the main cylindrical component of an electrically heated pressurizer, designed by Knolls Atomic Power Laboratory to Section VIII, of the ASME Code (Unfired Pressure Vessels) for use in the new Engineering Test Reactor facilities at Idaho Falls, Idaho.

This 66¼" long cylinder, 27" O.D. with walls 2½" thick, was centrifugally cast of an 18-8 stainless steel (SA-351, Grade CF-8) for the extra corrosion resistance required under nuclear loop service conditions: demineralized water at temperatures to 650°F and pressures to 2500 PSI.

O. G. Kelley Co., Boston, to whom we delivered this 2-ton, fully machined cylinder, welded on the forged heads and nozzles, radiographed the welds, and hydro tested the completed vessel to 4300 PSI.

This is another example of the adaptability of Sandusky Centrifugal Castings to applications demanding the highest order of quality. They may well offer you a practical and economical answer to your cylindrical needs, also.

We are producing cylinders and piping in diameters from 7" to 54"—in lengths to 33 ft.—in a wide range of ferrous and non-ferrous alloys. Write for Bulletin 300, for more complete technical information on the Sandusky process and product application data.

SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.

SANDUSKY, OHIO—Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

5983

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RB&W FASTENER BRIEFS

MAKING THE MOST OF MODERN MECHANICAL FASTENING

Technical-ities

By John S. Davey

Quick facts on cold heading

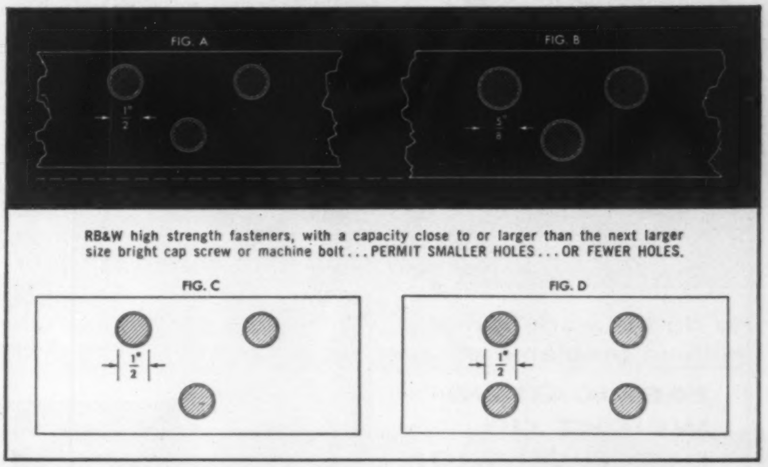
Compared to machining, cold heading gives stronger pieces at less cost. Also, the headers automatically control quality because unsound material cannot be used. While the scope of cold headers is wide indeed, it pays to design for them right at the start.

Some rules of thumb to guide you:

1. You save money after a run of 25,000 pieces (which pays for the set-up).
2. Maximum length of parts runs about 6 inches. Maximum volume of upset is equivalent to length of stock 4½ times its own diameter. (With special operations, up to 26 diameters have been achieved!)
3. Various metals and alloys are suitable. But keep carbon content in steel to under 0.45.
4. Concentric pieces are easier to form, though eccentric and serrated shapes are practical.
5. Avoid sharp corners. Allow generous radii.
6. Because upsets are usually cylindrical, oval or round shapes take less trimming than square or rectangular.
7. Hollow upsets tend to form cracks at edges of recess, so avoid them.
8. Embossing raises costs.
9. No problem heat treating short sections. But long sections are apt to be distorted.

When in doubt, contact an expert in cold heading.

How high strength fasteners affect the holes they fill



RB&W high strength fasteners, with a capacity close to or larger than the next larger size bright cap screw or machine bolt... PERMIT SMALLER HOLES... OR FEWER HOLES.

As simple a matter as the selection of fasteners can permit changes for better design... and also improve production costs and service life.

In sketch "A", for example, you see one difference from use of RB&W high strength fasteners instead of machine bolts or bright cap screws, as in "B". You use a smaller size fastener. Holes are therefore smaller. The metal section, in turn, can then be smaller for a saving in material and weight. The costlier the materials (copper bus bars as a case in point), the more significant the cost savings.

In sketch "C", fill the 3 holes with ½" high strength bolts, and you have a load capacity close to 40,000 pounds. That's the same as developed by 4 bright cap screws filling holes in Sketch D. It costs less to drill and less to fill the 3-hole design.

RB&W High Strength Fasteners are now identified by this new marking as well as 3 radial dashes. They have the proper balance between ductility and hardness required in high carbon units.

EFFECT ON PERFORMANCE AND PRODUCTION

When tightened to their full load, high strength fasteners not only *stay* tight—even under vibratory conditions—but also exert high clamping force. It has been shown that, under high compressive forces, hole areas gain extra resistance to fatigue cracks.

What's more, the high friction developed virtually locks members together, prevents slippage. Holes, therefore, need not be perfectly aligned since they can even be slightly oversized without detriment.

There's an RB&W Fastener Man ready to aid you in working with high strength bolts—in the design stage or as replacement for SAE grade 1 or 2 steel fasteners or for rivets. Write for helpful booklet DC-2, Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

For more information, turn to Reader Service card, circle No. 368

TAILOR-MADE PLASTIC TANKS

AVAILABLE FROM STOCK!

to do the work of metal without problems of

FABRICATION, WEIGHT OR DETERIORATION

If your business involves gases, chemicals, or liquids, you know the problems resulting from conventional containers.

We can truthfully say that SF seamless reinforced plastic tanks *lick* most of those problems. For example, SF tanks —

won't corrode . . . won't dent or rupture . . . insulate well . . are fire retardent . . . won't conduct electricity . . . can have permanent color and identifying marks "built in"...and can be machined, ground, or threaded for fittings. Four standard sizes can be shipped immediately from stock . . . 6", 8", 10", and 13" diameter.

It will pay you to call or write Structural Fibers *now*. Whether it's tanks or tubs or parts, we'll tell you what is possible and whether it's practical!

structural fibers, inc.

FIFTH AVENUE • CHARDON, OHIO

REINFORCED PLASTIC PRODUCTS BY THREE PROCESSES:

- internal pressure molding
- matched die molding
- premix molding

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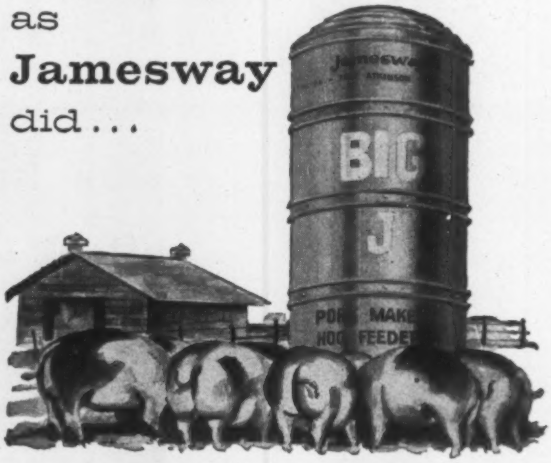
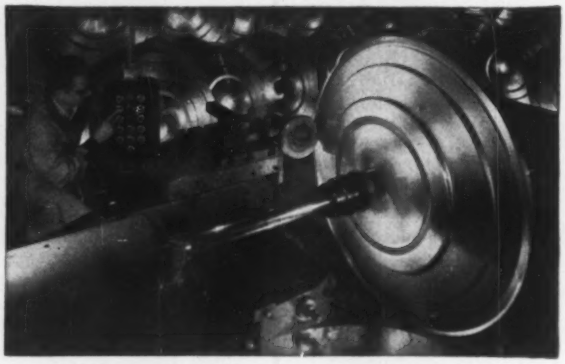
Don't Buy a Pig in a Poke! Try Spincraft as Jamesway did . . .



Spincraft designed and produced a rigid, lightweight, seamless hog feeder cover to replace an old high-cost, ugly riveted unit.
Result: Improved appearance, reduced cost.

Spincraft redesigned the feed spreader from a riveted, pie-cut piece to a seamless, precisely-sized cone.
Result: Rapid, effortless assembly; reduced cost.



You, too, may attain cost-reducing shortcuts and design improvements on your metalforming needs by calling upon Spincraft.

Write for Spincraft's Notes for an Engineer's File, a series of bulletins to keep you abreast of the latest metalspinning advances at Spincraft — the world's largest metalspinning plant.

Spincraft
SKILL WILL DO IT ®
INCORPORATED

4125 West State Street, Milwaukee, Wisconsin

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NICKELOID

HELPS MAKE A MAN'S WORLD

Fish lure, made of Nickel Brass.

Putting disc (Chrome Steel) and waste basket.

Ice bucket, tongs, tray, and bottle holder—all made of Nickeloid Metals.

Hair brush, made of Red Goldbond Steel.

Torpedo Level. The metal is Nickel Zinc.

Desk accessories, all made of Nickeloid Metal

Whenever a man is at work, at home, or at play—his world is brightened by the utility and functional features of Nickeloid pre-plated metals. These durable, brilliant, and economical metals have been designed into so many articles for men because of their triple advantages: appearance plus basic production economy plus a finish that can "take it" as few other finishes can. Look about you . . . your desk, your home, your recreation room . . . note the many parts made of bright metals. Many of these, whether Chromium, Nickel, Brass or Copper, are quite likely to be fabricated from a Nickeloid Metal. Nickeloid Metals are available in sheets, coils, and strips—bright or satin—and in a beautiful range of stripes, patterns, crimps and textures. Write us for free Introductory Kit, which gives full information.

For more information, circle No. 320

NICKELOID METALS

Sales offices in principal cities

AMERICAN NICKELOID COMPANY, PERU 6, ILLINOIS
PLANTS: PERU, ILL. AND WALNUTPORT, PA.

MICCROSOL

the finest in Vinyl Plastisols

- **WE SPECIALIZE . . .** *and in the areas where we specialize – WE'RE TOPS*

- **DIP — — SPRAY**
  If you're interested in coating your product with the outstanding plastisol in the industry . . . let our sales engineers work with you.

Our new laboratory building

MICHIGAN CHROME and CHEMICAL CO.

8615 GRINNELL AVE., DETROIT 13, MICHIGAN

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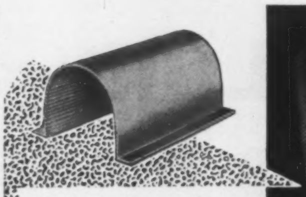
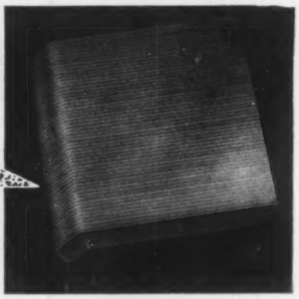
For more information, turn to Reader Service card, circle No. 403





other extruders said it couldn't be done . . .

GENERAL DID IT!

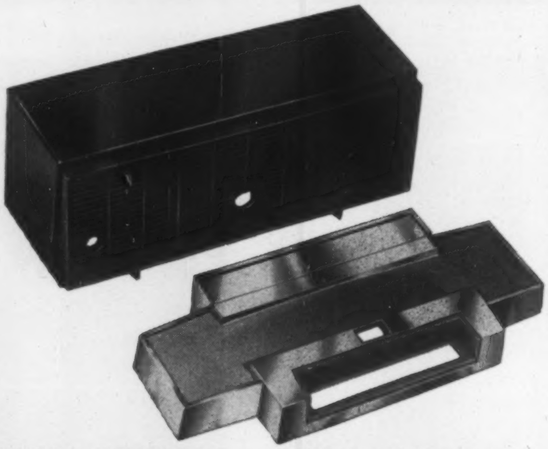
The manufacturer of heaters wanted a hearth bottom — a fluted, gold-anodized aluminum extrusion. Specifications called for a 7" x .050" shape. Extruders with presses that take 8" diameter billets said it couldn't be done because of the thinness, too great a reduction ratio.

G.E.I. engineers came up with the extrusion, on a 5" press! The shape is extruded half round, then straightened, notched and bent, holes punched, and finally gold-anodized.

If you have a problem involving aluminum fabrication, finishing or extrusion, why not take it to General, pioneers in developing new uses for extruded aluminum.

GENERAL EXTRUSIONS, INC.
4040 LAKE PARK RD., YOUNGSTOWN, OHIO
Sales Offices at St. Louis, Detroit, Pittsburgh, Cleveland, and Chattanooga

Consult your classified phone book under Aluminum Products



RADIO CABINET . . . HI-FI ESCUTCHEON

. . . precision-molded by SINKO

Of high-temp Styrene, the above exemplify the quality inherent in Sinko Moldings. It's no wonder therefore that some of the country's leading makers of Radio, TV, HI-FI, Refrigerators, and other appliances look to us for accurately molded and finished Plastic Parts and Products . . . *economically produced.*

Call on us when you need Plastic Moldings!

WE MOLD ALL THERMOPLASTICS . . . from 2 to 175 oz.

Sinko MANUFACTURING and TOOL CO.
7310 W WILSON AVE · CHICAGO 31, ILL

Offices in Principal Cities Throughout the United States

For more information, turn to Reader Service card, circle No. 346

You just roll this sealer on! 3M Ribbon Sealer EC-1202

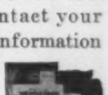
ROLL-ON RIBBON SEALER EC-1202 creates a uniform, economical, durable seal that shuts out water, dust and moisture.

It's easy to shut wind and weather out of mobile homes with 3M Sealer EC-1202. You just roll this synthetic rubber ribbon on, apply the next piece of metal . . . and fasten mechanically right through the sealer.

Because it's fabric-reinforced, EC-1202 holds its shape, doesn't stretch, sag or shrink. It applies just as easily along curved surfaces.

In mobile homes, this roll-on ribbon makes a weather-tight seal at lap seams and window beddings. And EC-1202 serves boats, curtain walls, commercial refrigeration, too. It's available in various widths and thicknesses direct from your local jobber.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU! Consult 3M Research. Contact your 3M Field Engineer. Or for information and free literature write: A.C.&S. Division, 3M, Dept. SAZZ-10, 900 Bush Ave., St. Paul 6, Minn.



ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

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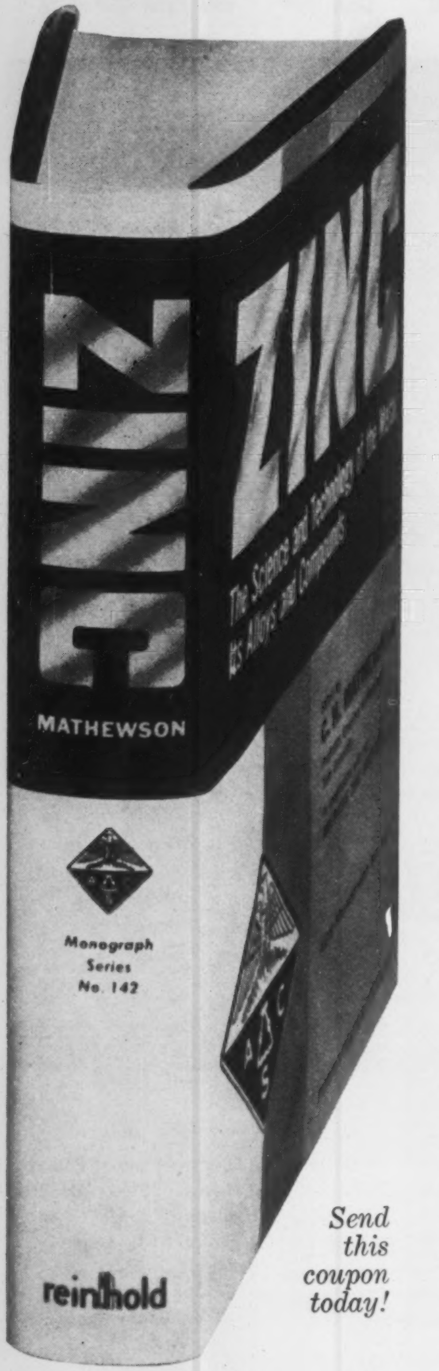
Just Published!

1959, over 700 pages, $19.50


ZINC
ZINC
The Science and Technology of the Metal Its Alloys and Compounds
MATHEWSON
Monograph Series No. 142
reinhold

ZINC

The Science and Technology of the Metal, Its Alloys and Compounds

Edited by C. H. MATHEWSON
Professor Emeritus of Metallurgy and Metallography, Yale University
With Chapters by Specialists
In Cooperation with THE AMERICAN ZINC INSTITUTE

ACS Monograph No. 142

This definitive monograph on the metallurgy, chemistry, extraction and uses of zinc is the most complete book ever published on the subject. Forty-five specialists under an outstanding editor-in-chief blanket the field from geology through the end product. Written with the cooperation of the American Zinc Institute, the book's fourteen chapters cover such topics as economics, geology, ore treatment, refining, processing, alloy technology, the use of zinc for extraction of other metals, zinc compounds, the biological significance of zinc, and its use in agriculture. All these subjects are in addition to the basic technology mentioned above. Here is a single source of information for anyone with a general or specific interest in zinc as a major material of modern industry.

CONTENTS

Historical Background
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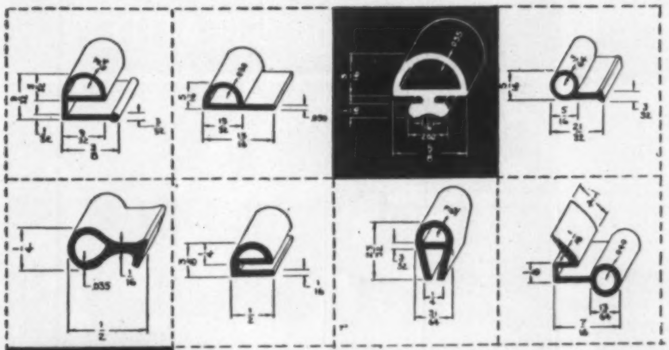

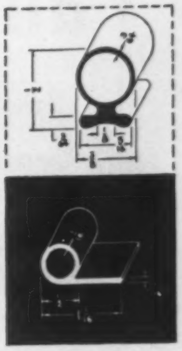

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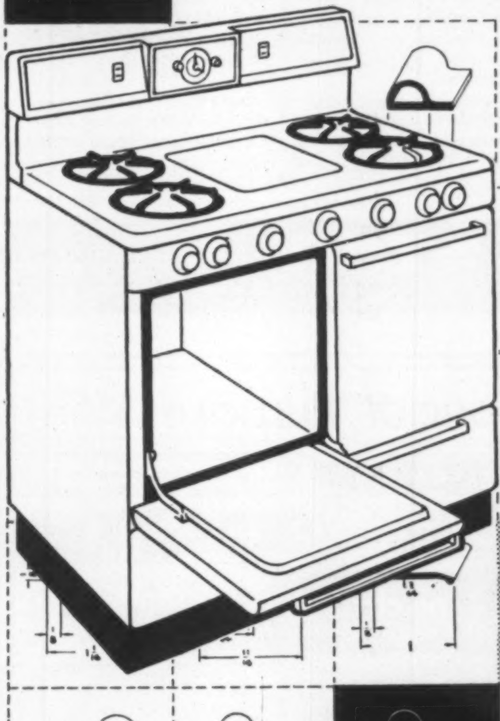

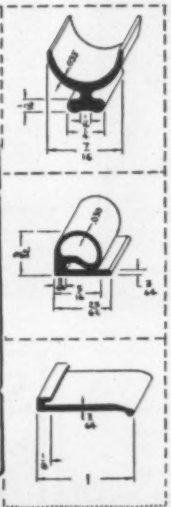

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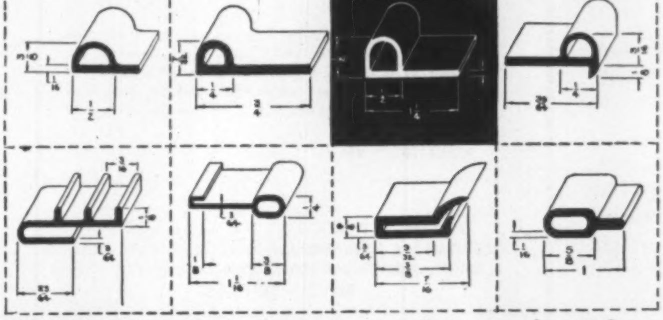

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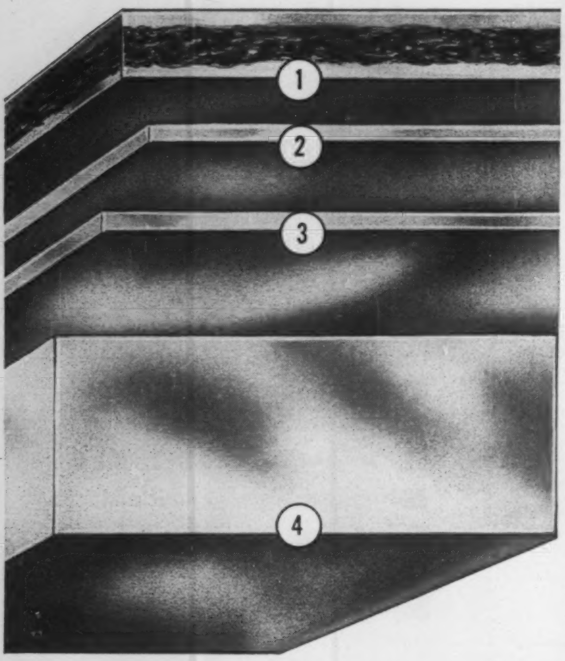

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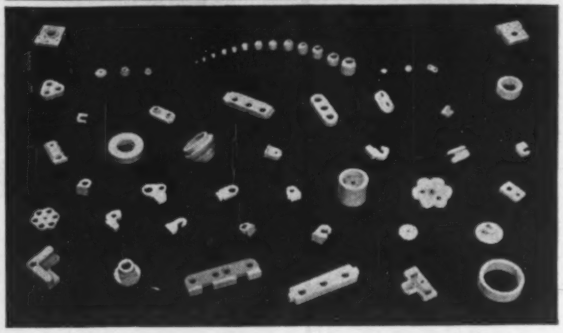

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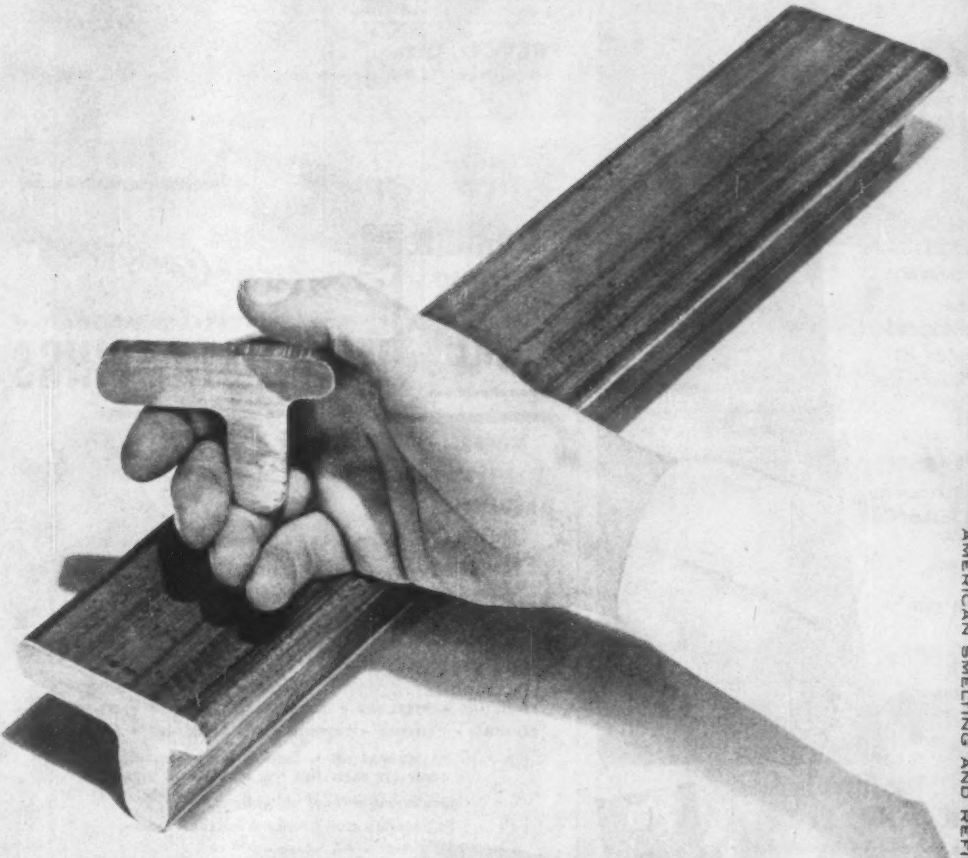

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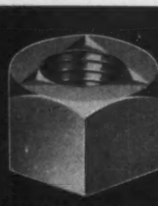

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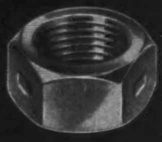

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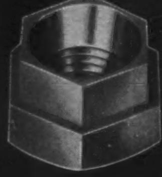

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Sub-Zero	SZHC657	6.5	−140° F.	−125° F.	60"	28"	42¾"	47"	15"	16"
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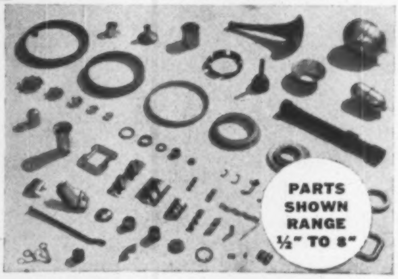

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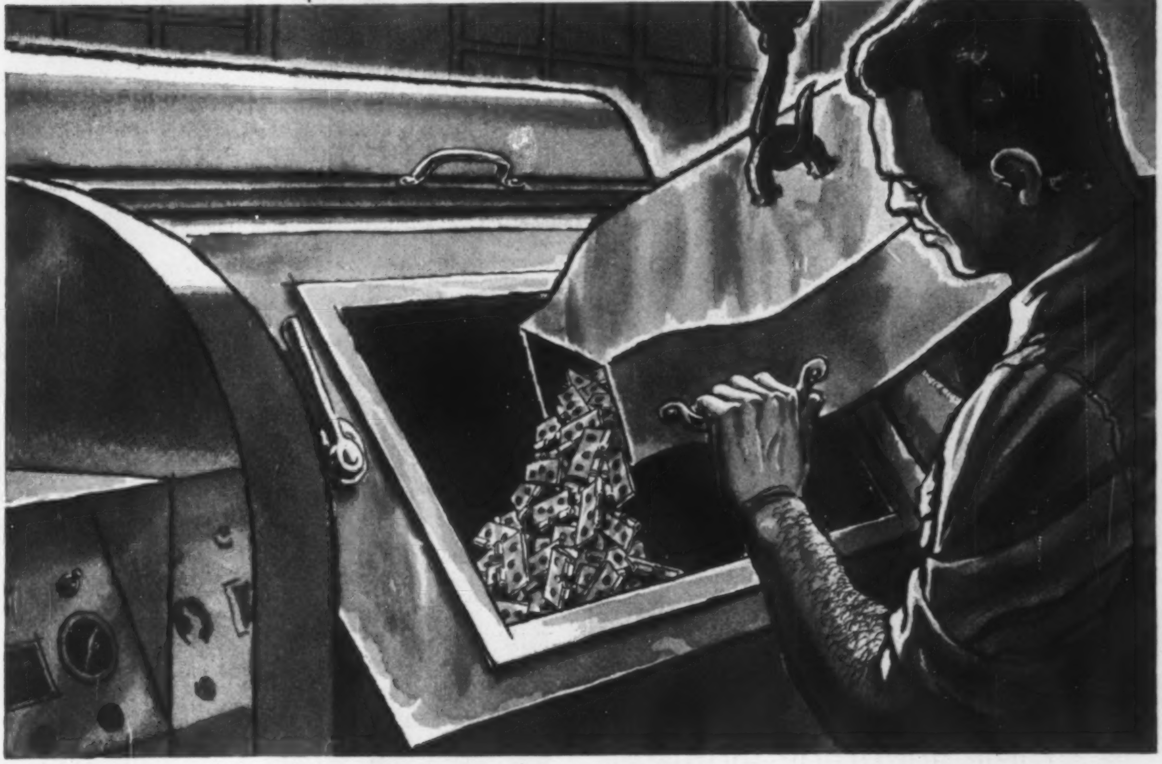

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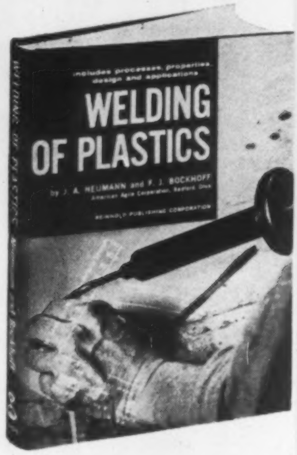
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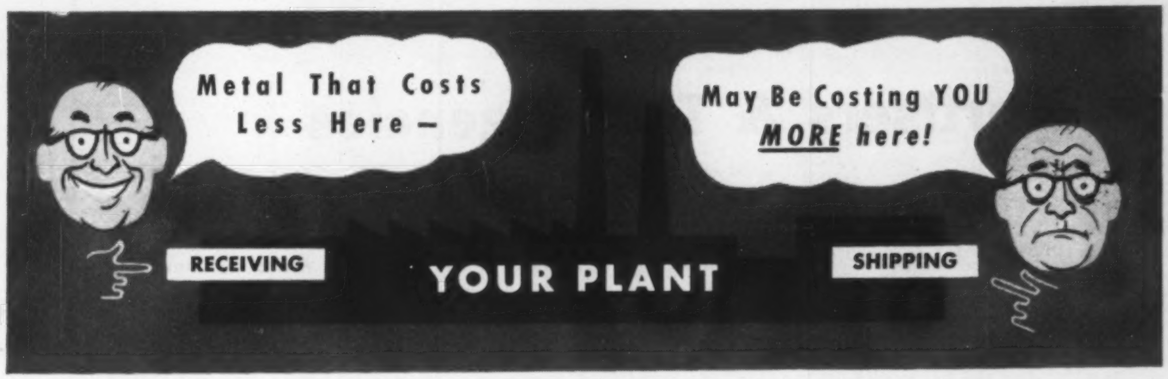
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THE LAST WORD

We 'Redesign' Our Product

by H. R. Clauser
Editor

In many ways publishing a magazine is like designing and producing a product. Just as most products are constantly being redesigned, so magazines are frequently revamped.

This issue, you may have noticed, is a "redesign." The major elements or parts that make up the "assembly" have been rearranged to produce, we hope, a more readable magazine. Instead of having just one so-called feature section, we have now distributed our major editorial content among three main sections. The first section in the magazine is What's New in Materials. It is our news section and covers the latest developments in the materials field. The second major section is titled Engineering and Design (see page 87). In it you will find articles dealing with properties, evaluations, comparisons and design characteristics of materials, materials forms and finishes. Directly following is the Materials at Work section (page 125) which, as in the past, will bring you idea-generating articles on applications of engineering materials.

Besides these three major sections, we have retained, of course, our regular departments such as Technical Literature, News of Industry and Prices and Supply.

This "redesign" was made to help you get the information you need faster. We hope it works. Let us know if it doesn't.

Too Many Awards Programs?

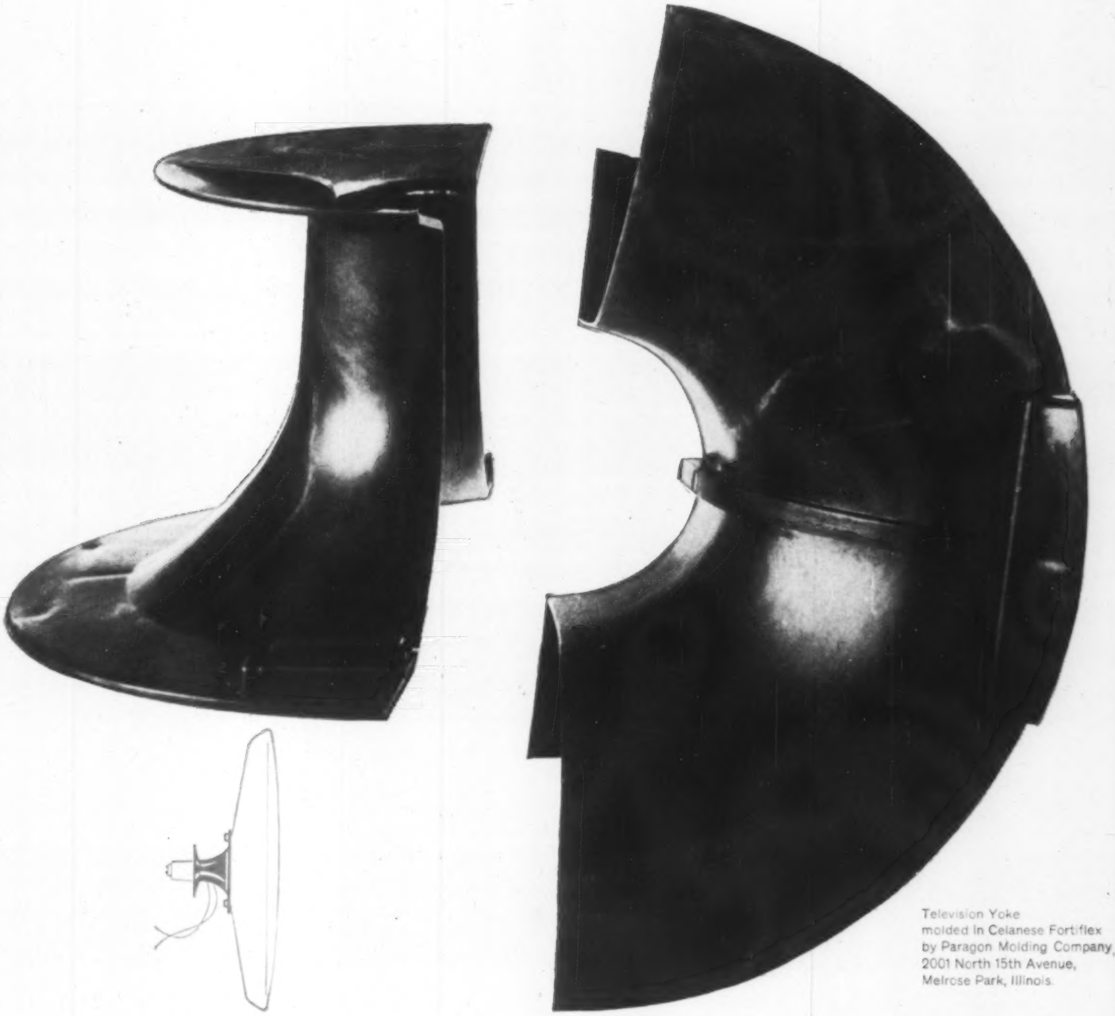
It seems that nearly every material and form of material is now represented by a contest or achievement award of some kind or other. During the past year, I have served as a judge on two awards committees and have been consulted by several organizations who are starting awards programs. And we have run announcements in M/DE on at least a half dozen others.

Some people have remarked to me that the profusion of awards in the materials field has tended to cheapen all of them. While there may be some truth in this, I can't see any great harm being done.

Competitions are an excellent way to stimulate better and more imaginative work. And they often provide a kind of progress or status report on the level of work being performed. They not only reveal the high quality performances but often uncover the fact that there isn't much good work going on in a particular field or area.

We, too, have an awards competition. Its purpose is to encourage the imaginative use of materials in product design. I think we have good grounds for claiming that it is different from most of the others because it covers not one but all engineering materials and forms of materials. Also, because of its wide scope, it serves the function, mentioned earlier, of providing a good estimate each year of the general level of work being done in materials selection and use.

Incidentally, the current competition closes February 1 (see details, p 138). If you haven't already entered, look at your work completed over the past year, pick the best, and enter it.



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More information is available. Write today for New Product Bulletin NP-35. Celanese Plastics Company, a Division of Celanese Corporation of America, Dept. 102-A, 744 Broad St., Newark 2, N. J.

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